

Learning and Labor.

LIBRARY

OF THE

University of Illinois.

CLASS.

BOOK.

VOLUME.

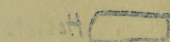
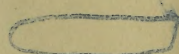
630

Un3c

26-30

Accession No.





Find in
the
of vol.

U. S.

Department of Agriculture

Chemistry division

Bulletins

volume

4

nos. 26-30

Contents

- 26- Wiley- Production of sugar
from sorghum in
1889
- 27- Wiley- Culture of the sugar
beet
- 28- Association of agricultural
chemists- Proceedings of
seventh annual
conventions
- 29- Wiley- Experiments
with sorghum in
1890
- 30- Wiley- Experiments with
sugar beets in 1890

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 26.

RECORD OF EXPERIMENTS

IN THE

PRODUCTION OF SUGAR FROM SORGHUM

IN

1889

AT CEDAR FALLS, IOWA; RIO GRANDE, NEW JERSEY; MORRISVILLE,
VIRGINIA; KENNER, LOUISIANA; COLLEGE STATION, MARYLAND;
AND CONWAY SPRINGS, ATTICA, MEDICINE LODGE,
NESS CITY, LIBERAL, ARKALON, MEADE,
MINNEOLA, AND STERLING, KANSAS.

BY

H. W. WILEY,
CHEMIST.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1890.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 26.

RECORD OF EXPERIMENTS

IN THE

Compliments of

J. M. RUSK,

Secretary of Agriculture.

DEPARTMENT OF AGRICULTURE, WASHINGTON.

BY

H. W. WILEY,
CHEMIST.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

16150

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 26.

RECORD OF EXPERIMENTS

IN THE

PRODUCTION OF SUGAR FROM SORGHUM

IN

1889

AT CEDAR FALLS, IOWA; RIO GRANDE, NEW JERSEY; MORRISVILLE,
VIRGINIA; KENNER, LOUISIANA; COLLEGE STATION, MARYLAND;
AND CONWAY SPRINGS, ATTICA, MEDICINE LODGE,
NESS CITY, LIBERAL, ARKALON, MEADE,
MINNEOLA, AND STERLING, KANSAS.

BY

H. W. WILEY,
CHEMIST.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

46150

PREFATORY NOTE.

SIR: I have the honor to submit herewith, for your approval and inspection, a report on the experiments conducted under my direction during the past year relating to the manufacture of sugar from sorghum.

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary.

RECORD OF EXPERIMENTS IN THE MANUFACTURE OF SUGAR FROM SORGHUM IN 1889.

The experiments in the manufacture of sugar from sorghum conducted by the Chemical Division of the Department of Agriculture during the season of 1889 were divided into two classes, viz:

(1) Culture experiments; having for their object the improvement of the cane in respect of its sugar-producing qualities.

(2) Chemical control of the manufacture of sugar from the cane; having for its object the demonstration of the sugar-producing power of the cane entering into manufacture and the location of sources of loss.

In some cases the two classes of experiments were combined, as at Kenner, Rio Grande, and Attica; in others they were entirely separated, as at the Maryland stations and at Sterling. From the totally different character of manufacturing and culture experiments it is easily apparent that only the best results can be obtained in each case when the two kinds of work are kept entirely separate.

During the manufacturing season both proprietors and chemists must of necessity be primarily interested in saving the crop. In the face of this necessity the purely cultural part of the work must suffer. This same remark may be applied but with less force to the growing season. The important work at this time is to produce a crop ready for the mill, and but little thought and attention can be given to problems of producing new varieties and improving old ones. The experience of the last two seasons has furnished proof of the truth of the above theoretical conclusions. Only at those stations where no manufacturing operations have been carried on have the most valuable results been obtained in culture work, while at manufacturing stations the work of the chemical control of the factory has been made of paramount importance.

CHARACTER AND ALLOTMENT OF WORK.

On March 2, 1889, the bill appropriating the unexpended balance of last season's sugar fund, \$59,984.77, and granting an additional sum of \$25,000, became a law.

The change of administration which was to take place on the 4th of March induced the retiring Secretary of Agriculture to postpone all arrangements for work in this matter for his successor. The delays in-

cident to the induction of the present Secretary into office prevented any arrangements being consummated for the work until April 4, 1889. At that time I was authorized by the Secretary to make arrangements for certain culture experiments, and on May 4, 1889, I was directed by him to visit some of the places where it was proposed to conduct experiments and make a study of the conditions presented. On May 6, 1889, Mr. W. W. Cook, of Medicine Lodge, Kans., was commissioned by the Secretary as an agent of the Department to act subject to my instructions.

In May I proceeded under authority above mentioned to Kansas and Iowa and visited the stations at Attica, Conway Springs, Medicine Lodge, Sterling, and Cedar Falls. At the same time I directed Mr. Cook to visit other stations where sugar factories were building.

Information respecting proposed operations at Rio Grande, Morrisville, and Kenner was also obtained, and the results of all this work were collated in a report submitted to the Secretary on June 1, 1889.

The general conclusions reached by a study of the data obtained were as follows:

GENERAL CONCLUSIONS.

"I have endeavored to lay before you in the preceding report as many of the details of the present condition of affairs in the sugar region as are necessary for a proper understanding of the present conditions of the problem. It appears to me that the most favorable conditions for success in the manufacture of sugar from sorghum are found at the three stations of Conway Springs, Attica, and Medicine Lodge. Of these three the station at Attica is the most advanced; while the station at Medicine Lodge is the only one which, in my opinion, has a sufficient water supply. In case no delay is experienced by the company at Medicine Lodge in the erection of the machinery I shall expect to see the best results of the season's work at that place, Attica coming second, and Conway Springs third, according to present appearances.

I find all the people engaged in the business are underestimating the difficulties to be encountered and overestimating the appliances at hand. Some of the men engaged this year in the work have had many years' experience and yet they seem to be still oblivious to the most patent facts which have been developed especially by the experiments of the Department. The trouble seems to arise from a failure to investigate the matter from a non-partisan basis. One of the great difficulties in all the sorghum sugar ventures has been a lack of capital. In order to secure a sufficient investment of funds, I fear it has often been the custom to ignore the difficulties of the problem and to present only to the intending investor the rosy side of the question. It would appear, after the publication of Bulletin No. 20, in which the great danger of undertaking work in the manufacture of sorghum sugar without a sufficient water supply was fully pointed out, that one of the first things to be looked after by the intending builders would be a supply of water sufficiently abundant for all possible emergencies. Instead of having

done this we find that in Kansas only one factory has been placed where the water supply is practically inexhaustible.

The chemical force at my disposition was assigned as follows:

To Cedar Falls, A. E. Knorr; Rio Grande, H. E. L. Horton, assisted by G. E. Rockwood; Morrisville, W. Maxwell; Conway Springs, E. A. Von Schweinitz, assisted by Mr. Meechem and J. G. Hoffman; Attica, Oma Carr, assisted by Lewis H. Bradford; Medicine Lodge, Hubert Edson, assisted by T. F. Sanborn; Ness City, K. P. McElroy, assisted by S. B. Merrill; Liberal, Arkalon, and Meade, J. L. Fuelling, assisted by Erwin E. Ewell; Sterling, C. A. Crampton, assisted by M. B. Clement.

Only one chemical outfit was provided for the three stations at Meade, Arkalon, and Liberal, because these three stations were under the same control near together and similarly situated in respect of soil and climate. Moreover it was found impracticable to equip and use an additional number of laboratories.

It may not be complimentary to the agricultural chemical education given in our schools, but nevertheless it is true that it was impossible at the time to secure additional chemists competent to exercise the control desired. Inasmuch as the necessary technical knowledge for such work is easily attained, it is to be hoped that another season will see a number of agricultural chemists prepared for such work sufficiently large to satisfy all demands. In view of the rapid increase in the number of sugar factories requiring chemical help it might be well to consider the propriety of establishing a special school in which instructions could be given in the theory of sugar production and manufacture, the school being transferred to the sugar belt during the manufacturing season for practical instruction. Graduates of agricultural colleges who have paid proper attention to chemistry should be able in one year under proper instruction, as outlined above, to take charge of chemical work in a sugar factory.

Since the establishment of an indigenous sugar industry is a matter of the greatest national importance, it would seem proper for Congress to take the initiative in the establishment of a national sugar school.

In addition to the work done by the stations named the chemical work of the College Station culture experiments was done in this laboratory by Messrs. Trescott and Dugan. The samples of cane were sent in each morning by express, reaching the laboratory by 9 o'clock.

The following brief statement of the equipment of the several factories in Kansas was prepared by Mr. G. L. Spencer:

THE SOUTHERN KANSAS SUGAR COMPANY, CONWAY SPRINGS, KANS.

Estimated capacity.—The capacity of the works is estimated at 200 tons of clean cane per twenty-four hours.

Steam.—The steam is supplied by four multitubular boilers of 150 horse-power each.

Cane-racks.—The cane is unloaded directly from the farmers' wagons upon long

racks, whence it is drawn by machinery to the carriers. These racks have storage capacity for sufficient cane for the night's work.

Cutters.—The preparatory cutter consists of two circular disks of iron fitted with a shaft, etc., and carrying two heavy knives. The knives are bolted to the opposite parts of the circumference of the disks in such a manner that when the cutter is in revolution their edges describe a cylinder. They are set parallel to the shaft. A third disk of lighter weight supports the knives at the central point and prevents their springing.

The following are the dimensions of this cutter: Diameter, 30 inches; length of knives, 3 feet in the clear; diameter of shaft, 4 inches; thickness of the disks at the rims, 4 inches; driving pulley, 14 inches diameter by 8 inches face. The speed of the cutter is approximately 230 revolutions per minute.

The carrier ends about 3 feet from the cutter and a few inches higher than the dead-knife, delivering the cane upon an inclined chute. Two rollers forming a forced feed carry the cane to the knives. The cane leaves are separated from the cuttings by a series of fans.

The shredders.—The shredders, two in number, are of the Hughes system. Their dimensions are as follows: Length of cylinder, 24 inches; diameter, 8 inches; shaft, 2½ inches diameter; driving-pulley, 12 inches diameter by 6 inches face. Each cylinder carries four knives.

The cutters and shredders were built by the Kilby Manufacturing Company.

Diffusion batteries.—The works are provided with two diffusion batteries, one of which was constructed and operated in 1888. This battery has a net cane capacity of 50 cubic feet per cell. The upper and lower doors are the full diameter of the cell. Solid rubber gaskets are used for the lower doors instead of the hydraulic closure. It is significant that the battery of the Attica Company by the same designer is provided with the hydraulic closure. The juice and water mains are 3 inches in diameter. These mains are too small for rapid work. The heating surface of the calorimeters is also insufficient. A comparison of the analytical work of this battery and the new one about to be described will be of value in determining the influence of the form of the cell as affecting the extraction and dilution.

The cells of the second battery, constructed by the Kilby Manufacturing Company, are similar in form to those at Magnolia plantation (see Bulletin 21), differing only in having a slightly larger diameter at the discharge door than at the shoulder.

The object of this increase in the diameter is to facilitate the discharge of the exhausted chips. The lower doors are operated from the upper platform by an hydraulic attachment. The net capacity of each cell is 65 cubic feet of chips. The juice and water mains are 4 inches in diameter. This battery seems well proportioned for rapid and effective work.

The batteries have twelve cells each and are arranged in single lines, parallel with one another. One set of men operates both batteries.

Exhausted Chips.—The exhausted chips are dumped into carts and hauled to the fields.

Clarification.—A continuous clarifier (see page 8, Bulletin 17), similar to that employed at Fort Scott in 1887, was the only means of clarification in use the first part of the season. This apparatus was insufficient both as regards capacity and efficiency. It is the intention (September 7, 1889) to increase the clarifier capacity by the addition of several of the ordinary form of clarifiers.

Evaporation.—The juice from the clarifiers, after settling in tanks, is concentrated in a 15-coil Yaryan double-effect.

Granulation.—The sirups are boiled to grain in a vacuum pan of the ordinary form.

Centrifugals.—Six Hepworth centrifugals are employed in purging the sugars.

Water supply.—The water supply is drawn partly from a creek and partly from a large well used last season. The water from this latter is strongly impregnated with gypsum. The pipe line from the creek is of insufficient capacity.

THE MEDICINE LODGE SUGAR WORKS, ELDRED & HINMAN, PROPRIETORS, MEDICINE
LODGE, KANS.

Estimated capacity.—Capacity 200 tons of clean cane per twenty-four hours. The machinery is probably of a capacity considerably greater than the guaranty.

Buildings.—The main building is 148 feet by 48 feet, the boiler house 50 feet by 90 feet, the laboratory and office 60 by 20 feet.

Location of machinery.—The water pumps and the receiving tank for the condensation are in the boiler-house.

The central portion of the main building rises about 40 feet above the main roof and contains the pressure tank and the water supply for the Yaryan and the strike-pan.

All the pumps, engines, etc., are on the ground floor. The battery extends in a single line parallel with the length of the building. The cutters, shredders, and pans are on the opposite side of the building near the battery.

The Yaryan double-effect and the vacuum pan are on the second floor opposite the battery.

The centrifugals are in the east end of the building conveniently located in regard to the vacuum pan and the hot room.

Steam.—The steam supply is obtained from six 125 horse-power multitubular boilers.

Cane-racks.—The racks for the storage of cane have an estimated capacity of 150 tons.

Cutters and shredders.—The cutters and shredders are from the same patterns as those at Conway Springs. The leaves are separated as usual by means of fans, and are then carried outside the building by a Sturtevant exhaust-fan.

Diffusion battery.—The cells of the battery are larger in diameter at the bottom than at the top, the average being 50 inches. They have a net cane capacity of 105 cubic feet.

The shredded cane is distributed to the battery, which is arranged in a single line, by means of an endless belt. The battery is composed of twelve cells and differs from that at Conway Springs only in being of larger dimensions.

Exhausted chips.—The exhausted chips were to be carried 100 yards or more distant from the building in a cable car provided with an automatic dumping arrangement, but owing to the failure of this car the chips were flushed into a creek by the waste water from the multiple-effect and strike-pan.

Clarification.—The ordinary method of clarification as used in Louisiana is employed.

Evaporation and granulation.—A 15-coil Yaryan double-effect is employed for the concentration of the juice, and a vacuum pan, 8½ feet diameter, for the granulation of the sugars.

Centrifugals.—The centrifugal equipment consists of five machines, Hepworth's latest improved.

The water supply.—The water is derived from Elm Creek. This is the only sugar-house visited by the agent of the Department whose owners seemed to realize the fact that a sugar-house requires an immense volume of water. The water pumps are very powerful and the supply of water ample.

The house was built and equipped by the Kilby Manufacturing Company.

THE ATTICA SUGAR COMPANY, ATTICA, KANS.

Estimated capacity.—The estimated capacity of these works is 200 tons per twenty-four hours.

Steam.—Two Hazleton tripod boilers, one of 400 horse-power, and the second of 300 horse-power furnished ample steam for the sugar-house. A Rooney automatic stoker is attached to one boiler.

Cane-racks.—The cane racks have storage capacity for 120 tons. They are so arranged that the cane can be delivered to the carrier in bunches. This facilitates the removal of the seed heads.

Cutters and shredders.—The cutters (two) do not differ materially from those at Conway Springs and Medicine Lodge, which are described elsewhere in this report. The carriers end abruptly a few inches from the cutters, leaving a space for the panicles, which are too heavy to be drawn in, to fall on a drag below. The shredders are also similar to those at Conway Springs and Medicine Lodge. They are two in number, each cylinder 24 inches long and 8 inches diameter.

Diffusion battery.—The diffusion battery single line arrangement consists of 12 cells each of 105 cubic feet capacity. The cells are provided with the hydraulic closure. The cane chips are automatically treated with powdered slacked lime before passing into the cells.

Exhausted chips.—The exhausted chips are passed through a five-roll mill preparatory to burning under the boilers. Owing to the weakness of the mills the extraction is poor, and consequently the chips are in a poor condition for use as fuel. Notwithstanding these difficulties this sugar-house burns a portion of its chips.

Clarification.—A continuous clarifier (see page 8 Bulletin 17) is employed in the purification of the juice.

Filtration.—The juice from the clarifier is filtered through ordinary presses. Before entering the filter-press it is treated with live steam, the steam also furnishing the pressure for filtration.

Evaporation.—A double-effect of the ordinary system (1,000 square feet heating surface per pan) is employed for the concentration of the juices.

Extra bottoms are provided for these pans, for use in salt manufacture. Also for this reason the pans are very high in proportion to their diameter.

Granulation.—The sirups are boiled to grain in vacuum pans of the ordinary form. This house is provided with two such pans.

Centrifugals.—The centrifugals, five in number, are of the Hepworth make (West Point foundry).

Water supply.—The supply of water is derived from a small creek, and is hardly sufficient for the needs of the house.

THE SOUTHWESTERN SUGAR COMPANY.—WORKS LOCATED AT MEADE, ARKALON, AND LIBERAL, KANS.

These three houses, built by one manufacturer, differ but little in arrangement and are of equal capacity, hence a description of one will answer for the three.

Estimated capacity.—The rated capacity of each house is 150 net tons per twenty-four hours.

Steam.—The steam is supplied by six multitubular boilers of approximately 75 horse-power each.

Cane platform.—The method of handling the cane is very simple and deserves especial mention. The carrier extends the entire length of the center of a broad platform; the sides of the carrier form a guide and support for a movable frame to which a block and fall are attached. When a load of cane is to be discharged, the wagon is backed up to the platform, the frame is moved to a part of the carrier opposite, and the fall is attached by means of two hooks to the ropes binding the cane; the free end of the fall is passed around a capstan driven by power. By means of this arrangement the cane is easily drawn off the wagon upon the platform convenient to the carrier. In case of difficulty in backing a wagon up to the platform, the fall can be attached and power be applied to bring it to the proper position. The platform has capacity for the storage of sufficient cane for the night work.

Cutters.—The preparatory or ensilage cutter is built upon an entirely different principle from those in use at other sorghum sugar houses. It consists essentially of two cranks similar to those of a locomotive, connected by a heavy knife; this lat-

ter replacing the parallel or side rod of the locomotive. It may be seen that the revolution of the crank-shaft communicates a drawing motion to the knife. An ordinary carrier delivers the cane to suitable feed-rolls, which in turn carry it forward upon a corrugated dead-knife, which latter prevents slipping when the knife descends to make the cut. The peculiar arrangement of this cutter enables it to make a smooth draw cut, without splitting the cane. This insures a more thorough removal of the leaves and trash by the fans. The seed heads fall through an opening between the feed-rolls and the cutter upon an auxiliary carrier, as in the Hughes system.

The dimensions of this cutter are as follows: Knife blade, one-eighth inch thick, 6 inches broad, and 50 inches long; two balance wheels 28 inches in diameter each; driving pulley, 24 inches in diameter, 8 inch face.

The shredders.—The shredders are of the Hughes system, so arranged that one can be employed while the knives of the second are being reset. These machines do not differ materially from those in use in the factories already described in this report. Dimensions: Diameter of cylinder, 8 inches; length, 24 inches; shaft, $2\frac{1}{4}$ inches diameter; driving pulley, 12 inches diameter, 6 inch face. Each cylinder carries six knives.

Diffusion battery.—The battery is arranged in a single line of fourteen cells. Each cell has a net cubical capacity of 60 feet. The lower doors are of the full diameter of the cells and are operated by block and fall. The hydraulic closure is employed for these doors. The juice and water mains are $3\frac{1}{2}$ inches in diameter.

Exhausted chips.—The exhausted chips fall into a cable car and are carried outside the building.

Clarification.—The ordinary method of clarification is employed.

Evaporation.—The juices are concentrated in a Swenson triple-effect apparatus.

Granulation.—The sugars are grained as usual in a vacuum pan.

Centrifugals.—The centrifugal equipment consists of three machines, Hepworth's latest improved.

On September 14 I was ordered to report to the Secretary in Chicago and accompany him on a tour of inspection in Kansas. The factories at Minneola, Meade, Arkalon, Liberal, Attica, Medicine Lodge, Conway Springs, and Fort Scott were visited during the latter part of September. The condition of affairs in most of the places visited was discouraging. At Minneola, Meade, Arkalon, and Liberal the drought had cut the cane crop short and the greater number of the fields of cane presented plants dwarfed, immature, and shriveled, thoroughly unfit for sugar making. Of the four factories first named, only one, viz, at Liberal, was found in operation. At Arkalon the work of construction was not completed, and water had not been found in sufficient quantity to operate the factory had it been ready for work. At Meade attempts were still making to secure water. At Minneola, where the roasting process was on trial, no water was available, but a few pounds of cane were passed through the furnace to show its mechanism. At Attica and Medicine Lodge the factories were found in operation, and at the latter place we found the only sufficient water supply of the stations receiving aid from the Department. At Conway Springs the factory was really shut down for lack of water and for some repairs, but was set in motion temporarily for inspection by the Secretary. At Fort Scott the factory was found to be running smoothly. The original machinery placed in this factory by the Department is still largely in

use, and the proprietors expressed their entire willingness to place all desired data in the hands of the Department.

The general impressions derived from this hasty tour of inspection were that the southwestern part of Kansas is too dry for growing sorghum for sugar under the present methods of culture, that the factories in that portion of the State had been mostly located without proper consideration of the water supply and possibilities of the soil and climate; that the crop of cane throughout the southern central part of the State was exceptionally fine and contained large quantities of available sugar, and that the factories in the part of the State last mentioned were far inferior to the capacities expected of them, with deficient machinery, in many respects incapable of continuous work, and with one exception operated with an insufficient supply of water. In general it appeared, from what could be observed, that financial success could hardly attend the present season's work, and that this unfortunate condition of affairs might have been avoided by the wiser investment of a larger amount of capital directed by a more judicious and extended experience.

REPORTS OF WORK AND OBSERVATIONS.

In order to obtain as much information as possible on all points connected with the sorghum sugar industry each of my assistants was directed to report to me in full the results of all analyses, facts disclosed by chemical control of manufacture, and all data relating to the crop, quantity of cane grown and purchased, loss in cleaning cane, sugar and molasses made, cost of manufacture, and all other data of a nature to elucidate the problem of sugar making. These reports¹ will be found appended to this bulletin.

It is due to the young men who had charge of the work at the various stations to say that a large part of the data collected was obtained by disregard of the conventional hours of official labor. A culture station or a sugar factory would have little use for a chemist who would refrain from presenting himself at the laboratory before 9 o'clock a. m., and at 4 o'clock p. m. promptly stop his work.

MANUFACTURE AND CHEMICAL CONTROL.

REPORT OF WORK AT CEDAR FALLS.

In addition to the report of the chemist, Mr. A. E. Knorr, of the work done at Cedar Falls, there is given the report of Bozarth Brothers, who had charge of the technical part of the experiments.

I can not add anything to the discussion of the data obtained at Cedar Falls more pertinent than a selection from the report made to the Secretary in June last.

¹On account of insufficient funds to print the whole of the report on sugar these reports are printed by abstract only. For the same reason only a small portion of the body of the report as originally prepared is found in this bulletin.

REPORT OF THE PROSPECTS AT CEDAR FALLS, IOWA.

"Clinton Bozarth and sons have for several years conducted very successfully a factory for the manufacture of sorghum sirup at Cedar Falls, Iowa. The company owns a well-equipped factory and about 100 acres of land situated on the left bank of the Cedar River, immediately opposite the town of Cedar Falls. The soil is very sandy and appears well suited to the growth of sorghum. The company has this year planted about 100 acres of their own land and have contracted with adjoining farmers for about 200 acres more. Three hundred acres of cane usually afford a sufficient amount of raw material to keep the factory in operation from twenty to twenty-five days. During the past season 40,000 gallons of molasses were made and sold at a fair profit. Some seasons, however, the cane is killed by frost before it has matured and the output of molasses is very much diminished in quantity and also inferior in quality. Killing frosts are usually expected early in September. Cedar Falls is situated in the northeastern portion of Iowa in the latitude of Dubuque. I have no hesitancy in saying that all expectations of ever successfully establishing a sorghum sugar industry in such a locality must end in disappointment. The company has a fairly good mill, a Louisiana No. 2, manufactured by George L. Squire, of Buffalo, N. Y., and convenient pans for clarification and evaporation of juices. The factory is without doubt one of the best appointed in the United States for the manufacture of sorghum sirup. I regret exceedingly that the proprietors have acquired the idea of making sugar, since, as I said above, it will be quite impossible for them to succeed from a commercial point of view. Some seasons, however, the cane is quite rich in sugar and large quantities of molasses have granulated and several thousand pounds of sugar have been made by separating these crystals from the molasses in a centrifugal machine. Perhaps one reason why the members of this company have been led to believe that they could manufacture sugar successfully is on account of a recent report issued by the Agricultural Experiment Station of Iowa, in which the profitable manufacture of sugar in that State is regarded as a possibility. The financial difficulties which such a report might cause by encouraging the investment of capital in hopeless enterprises could possibly be very great. I discouraged the members of the company in so far as possible from undertaking such experimental work in that locality, but did not succeed in convincing them of the impracticability of the endeavor. They are very much inclined to go ahead with the \$5,000 which have been conditionally promised them by the Department, and erect a small vacuum pan and centrifugal plant for the purpose of making these experiments. I assured the company that the Department would not probably aid it to a greater extent than \$5,000, and asked them to make a statement of the probable cost of the experiments and see if they could be made within the sum specified.

"I greatly fear that should the company undertake the experiments the cost will be greater than the estimates and that therefore the venture will be a source of financial loss instead of profit; nevertheless, I have laid before them the dangers which they will undergo and the difficult character of the work which they are to undertake, and if they enter into the matter it will be after full information in regard to all points on which they should be placed on their guard."

REPORT ON WORK DONE AT RIO GRANDE.

In Mr. Horton's report of the work at the Rio Grande station will be found an extension of the general report on operations at this place during the past eight years contained in Bulletin No. 20. The analytical data of each year were copied by Mr. Horton from the record books of the station kindly placed at his disposal by Mr. Hughes.

The most discouraging feature connected with the Rio Grande experiments is found in the deterioration of the cane for sugar-making purposes. For several years in succession the cane crop at Rio Grande has been unfit for making sugar. The causes of this deterioration are not easily discovered. Careful inquiry fails to show any exposure to admixture with broom-corn, a cause which according to Leplay led to the total failure of the sorghum plant in southern France. It is possible that the habit of fertilizing at Rio Grande to secure a large tonnage may have led to some depreciation of the sugar content of the crop. The character of the climate may have also had something to do with it. It is now firmly established that sorghum develops its maximum content of sugar in a season with little rain, which is a condition of a maximum quantity of sunlight. The records of the signal stations appended to Mr. Horton's report show that during the years in which observations were made these conditions of maximum richness in the cane were not always fulfilled. Experience has further shown that the largest and finest seed heads do not make the richest canes, yet it is a natural custom to select the finest looking heads for seed. This mistake will be remedied just as soon as the production of seed for planting and the growing and manufacturing of the crop shall have become separate fields of labor, as they must necessarily be. The quantity of seed required to plant an acre of sorghum is so small that both farmer and fabricant can well afford to purchase scientifically selected seed at a high price.

The method which should be pursued is the following: A single seed head from a cane of high available sugar content should be planted apart from all possible danger of admixture. There will then be produced a large number of canes of great uniformity of character and of high sugar quotient. The seed from their growth will be sufficient to plant many acres. Every field of cane grown for sugar-making purposes should be thus produced, since it would be impracticable to furnish the requisite quantity of seed directly from the polarized canes. The

great advantage that would accrue to the sorghum sugar industry from this method of seed selection is apparent without further elucidation.

On account of the low sucrose in the juice no attempt was made to manufacture sugar except from cane from a few small areas which indicated a sufficient quantity of sugar to secure crystallization. In the case of the small area which furnished the 2,900 pounds of sugar made, it is difficult to see why the cane in that portion of the field was saccharifacient, while in other portions, where all conditions were apparently identical, it was not so. This is another illustration of the vagaries of the sorghum plant, to which I have often called attention, and which serve to characterize it as one of the plants most susceptible to variation known.

From the small area of 2.9 acres in the upper end of the Morris Cresse field, 31.9 tons of cane (whole) were harvested. The mean content of sucrose in this juice was 11.14 per cent. On the basis of 88 per cent. juice in the cane, each ton thereof contained 1,760 pounds of juice. The percentage of extraction in the battery during this run was about 83 per cent. The total sucrose per ton of cane was 196.1 pounds. There was obtained per ton 99 pounds, polarizing 85 degrees=77.3 pounds pure sugar per ton. The loss of sugar in the battery in manufacture and in the molasses amounted to 118.8 pounds per ton.

No other attempts were made to produce sugar, although two other sections of the same field showed a sufficiently rich cane for that purpose. One of these produced cane yielding 10.67 per cent. and another 9.67 per cent. sucrose in the juice. These canes, however, were not worked for sugar. Inasmuch as over 200 acres were cultivated in cane and only 2.9 acres of this worked for sugar, the net result of the season's work, in so far as sugar-making is concerned, was decidedly negative in character.

The results of the last three years' experimental work at Rio Grande clearly demonstrate the fact that the only hope of successful sugar-making from sorghum in southern New Jersey must rest upon the production of cane decidedly richer in sugar than the average crop produced at that place since a record of its character has been kept. The character of the climate and soil would indicate that the sugar beet might be very successfully cultivated, and it would be extremely interesting to have some comparative experiments made with that plant. There are many reasons for expecting that the results of such experiments would be of the most hopeful character.

MACHINERY USED AT RIO GRANDE.

The machinery used at Rio Grande was of the same general type as that described in Bulletin 20. The battery constructed on the Hughes system of open cells and dipping baskets was entirely new and of greater capacity than those heretofore used. Many of the mechanical difficulties encountered in operating the first batteries of this kind

were remedied in the new apparatus, and its work was smooth and generally satisfactory during the entire season. The mean percentage of sucrose left in the chips as far as determined for the season was about 2.5 per cent. Based on the usual data this shows a mean extraction of 80 per cent. A special trial of the capabilities of the battery under the most favorable conditions was made on October 12. The mean weight of chips in each basket was 307 pounds. The mean quantity of water in each cell 368 pounds; the time of contact, *i. e.*, the time each basket remained in cell before transfer to next cell, was one and a half minutes, during which time the basket was dipped twice in the same cell. In the Hughes battery, consisting of ten cells, there is an additional cell called the eleventh, extraneous to the others, and into which the juice is drawn from the main battery. Into each charge of juice thus drawn the basket of chips next to be introduced into the battery is introduced and allowed to remain for one minute. The temperature of the juice in the eleventh cell was about 208° Fahr. The consequence of this immersion is at first the enrichment of the juice by contact with the fresh chips. These chips, however, enter the circuit of the regular battery with a less content of solid matters proportionate to the quantity given up by the first immersion. The final result must be to dilute the juice of the main battery to the extent of the matters extracted by the eleventh cell. In other words, the main battery works constantly on impoverished chips and the concentration of the diffusion juices therein is diminished to that extent. The final result of this process is therefore exactly the same as working with eleven cells in regular circuit. There is no compensation for the complicated mechanism of having one of the cells in a separate circuit.

The whole system of open-diffusion cells—which by the way was the first form of diffusion apparatus used—has long since been shown to be inferior in every respect to the closed system; and there is no conclusive evidence from the present year's experiments of any feature either of economy or advantage in the cost and operation of the apparatus. Designed originally to make sugar making economical on a small scale, it has gradually expanded into proportions of considerable magnitude without having given any indications of its ability to secure the original aim.

In fact there is now no more evidence than formerly of the possibility of manufacturing sugar economically on a small scale.

It is our duty to speak positively on this point. Every attempt to produce sugar on the farm or by combination of a few farmers must at present end in disaster, and there is every reason to believe that the future will show no greater encouragement to small factories. The manufacture of sugar requires such extensive and costly machinery as to relegate it to individuals or corporations with large capital and expensive apparatus.

Three seasons of experiment with the Hughes system of small fac-

tories have only confirmed the original views expressed from this office and serve to emphasize more strongly the absolute necessity of the best machinery constructed on the line of two great principles of sugar manufacture, viz, closed extraction apparatus and evaporation in vacuo. With our present knowledge it must be said that all attempts not falling within these lines must end in failure. To the farmer I say, content yourself with producing a crop rich in sugar and as high in tonnage as can be to obtain the object just named. To the manufacturer I say, use the best forms of closed diffusion batteries, simple clarification with lime, and the best methods of evaporation in vacuo.

There is one condition, however, in which I see a possibility of usefulness for the Hughes system of diffusion. There are two considerations which are kept in view in the extraction of sugar, viz, (1) the completeness of the extraction and (2) the density of the extracted juice. Theoretically the density of the diffusion juice can be made equal to that of the juice in the cane by an infinite number of cells in the battery, or an infinite number of dips in the Hughes apparatus. At first in starting a battery the hot water is speedily charged with the solids in solution in the cane cells, being brought into direct contact with the normal chips. In the regular running of a diffusion battery quite a different condition obtains. The extracted juice is brought only once into contact with fresh chips. We may regard normal diffusion as such a conduct of the work as allows complete equilibrium to be established between the circumfluent and intercellular juices, which in each case are equal in volume. The rate of diffusion depends, as is well known, on the size of the chips and the temperature of the juice. The smaller the chip and the higher the rise of temperature the more speedily will this equilibrium be established. The size of the chip, however, has more influence on this operation than the temperature. The theoretical normal diffusion would take place in a single cell surrounded by the diffusion juice. The superposition of cells such as is found in the ordinary cane chips and beet slicings entering the battery requires that the diffusion should take place in the exterior layer of cells and from one direction before it can begin with the interior layers. The time required for the diffusion through a single cell wall containing within a solution of sugar is not instantaneous but extremely minute. But the sum of the intervals required for the penetration of hundreds of cells successively becomes quite large.

In a normal diffusion of twelve contacts or twelve dips the relative concentration of the diffusion juice compared with the original juice in the cells of the plant can be calculated from the formula given in Bulletin No. 2, page 10. In practice, however, a larger quantity of liquid is used than in normal diffusion and the time of contact is not long enough in each case to secure complete equilibrium. With the apparatus now in use, therefore, we can not hope to obtain a relative density between diffusion and normal juice of more than 80 to 100. Any proposition

looking to the procuring of normal diffusion juice by allowing the time of contact to be extended beyond reasonable economic limits must be rejected for practical reasons. By reducing the size of the diffusion chips the normal diffusion juice can be more readily obtained. In the case of the beet, by reducing it to a fine pulp the normal juice, *i.e.*, complete equilibrium, is obtained in so short a time as to be practically instantaneous. On this fact Pellet has based his process for the instantaneous analyses of the beet by the aqueous method. No rise of temperature is required for this purpose, the equilibrium being established almost instantly in the cold. Sugar canes, both sorghum and sugar cane, reduced to a fine pulp would act in the same way. The mechanical difficulties of doing this are much greater than in the case of the beet on account of their more fibrous structure.

Nevertheless a cane shredder might be constructed which would furnish a pulp approximating in fineness the beet pulp above mentioned. In applying such a process practically, however, a point might be reached in the ordinary battery where the fineness of the chips would impede and finally prevent the circulation. This would arise from the fact that the pressure in such a battery is always in the same direction save in the first filling of the cell. The almost solid pulp thus formed might be more or less impervious to the circulation of the diffusion liquids. Now, if such a fine pulp can be produced in an economical way, it might be worked to great advantage in the Hughes battery. In dipping the basket into the cell of liquid the pulp would be raised and loosened and the perfect mixture of the pulp and liquid would be at once secured. The diffusion would take place almost instantly, the baskets could be quickly removed, and a small battery be made to do a great deal of work. In such a case I can easily see how a Hughes battery might be made to operate in a successful manner. The fact that such a diffusion could be carried on at ordinary temperatures would allow a purer juice to be obtained, since at high temperatures starch is rendered pasty and pectic substances rendered soluble.

Normal diffusion as described is secured when the added diffusion water is exactly equivalent in volume to the volume of juice in the substance under diffusion and where temperature and time of contact are so adjusted as to secure in each case complete equilibrium between the crystallizable bodies in the intercellular substance and the circumfluent liquid. When, therefore, it is claimed that diffusion juice of equal density with the intercellular juice is obtained in chips of the size usually employed it is at once evident that the operation has been carried on in some abnormal way, or that some factor in the process has been omitted. In the case cited in Mr. Horton's report it seems that the diffusion juice was almost equal in density to the normal juice in the cane chips employed.

The mean temperature of the cells during the trial run was 97° C. and the total time of contact seventy-two minutes for each cell. The enor-

mous surface exposed in the cells and by the chips when lifted, and by the juice dropping back into the cells from the uplifted baskets, doubtless cause sufficient amount of evaporation to account for this abnormal result. To work the battery in the way taken to secure the result would be far from economical and the results obtained are interesting more from their abnormal than practical interest.

CULTURE EXPERIMENTS AT RIO GRANDE.

In addition to the manufacturing experiments at Rio Grande some interesting data were collected concerning culture. A special plat of ground comprising several acres was laid out in plats and planted with some thirty varieties of seeds grown by the Department at Sterling. Unfortunately the seeds were found to be mixed, and although a vigorous growth on all but a few plats, yet owing to the admixture above noted and the lateness of the season no analytical examination of these plats was undertaken. Some most interesting problems were presented in connection with the Morris Cresse field. This field is fully described in the appended reports.

The time between plowing the upper and lower end of the field was only four days, and this interval can hardly account for the great difference in the composition of the cane grown on the different sections. The cane was harvested in six sections and the mean content of sucrose in the juice from each section, beginning with the upper end of the field, was 7.62, 8.09, 7.25, 9.67, 10.67, and 11.14 per cent. respectively.

The expectation of Mr. Hughes to compensate for late plowing and a consequently short season by nitrogenous fertilizing is a rather surprising one. The well-known properties of nitrogen in promoting vegetation and consequent longevity of the plant would lead us to expect just the contrary effect described by Mr. Hughes. A quick-maturing plant, though one yielding, of course, less tonnage per acre, would have been secured by growing the crop in uncloved fields and with a fertilizer in which phosphorus and potash were the predominant elements. Considering the late plowing and the wet season a more unfortunate selection of fertilizer could hardly have been made. It may be that the low sucrose content appearing in the Rio Grande canes during the past few years is partly due to the prominence given nitrogen in the fertilization. Yet, on this point no statements can be made with authority, but only by inference, for the history of fertilizing sorghum is still too young to form a basis for any practical conclusions. The results of a single season's work in such a case can only be accepted as indicative and not as final. Many years of varied trial in seasons of every kind and on diversified soils must elapse before a final judgment can be formed. The beginning made in New Jersey is valuable and will doubtless lead in time to more valuable theoretical and practical results. The variations in the sugar content of the various sections of the field illustrate

the difficulty heretofore encountered in obtaining sorghum of high uniform character for manufacturing purposes. In uniformly dry and mild seasons, such as have been experienced in Kansas during the past two years, a reasonable degree of uniformity has been reached where the samples have been taken over widely extended areas. In less favored localities all hope of securing such uniformity, it seems, must be abandoned. The culture results at Rio Grande serve to confirm the opinion hitherto expressed by me that the area for successful sorghum sugar growing is a restricted one, and that in the work of the last three years in central Kansas most valuable indications have been obtained of the probable location of the most favorable soil and climate for sorghum. This opinion is not expressed to deter any one from making culture experiments in other localities, but rather to call attention to the most promising field of operations. Sorghum at present is so far inferior to the sugar beet and sugar cane as to require the help of the most favorable soil and climate in order to maintain its existence as a sugar-producing plant. It is the part of wisdom in such cases to follow the most promising path and to leave the more difficult ones for future explorations.

MANUFACTURING WORK AT MORRISVILLE.

The results of the manufacturing trials at Morrisville are tersely summarized by Mr. Maxwell at the close of his report in the following words: "If a remunerative crop had been produced the mill was not in order to work it, and if the mill had been ready to work there was not a crop to be worked."

The mill was hastily constructed and presented in rather an unusual degree the difficulties attending the trials of new machinery.

The battery on the Hughes system was designed to have a capacity of 45 tons of field-cane per day, but, by defects in the machinery for cleaning and shredding the cane, rarely more than 20 tons were worked. No sugar whatever was made and the molasses manufactured was of a very inferior quality. It is the old story so familiar in sorghum literature—imperfect machinery, disastrous delays, vexatious accidents. Surely the science of mechanics and the skill of the machinist were never so coy with any other industry.

CULTURE EXPERIMENTS AT MORRISVILLE.

The result of the culture experiments at Morrisville is rather the record of the successive disastrous floods which prevailed over the cis-Alleghanian part of the United States during the season of 1889 than of any valuable information gained.

The agricultural part of the work at Morrisville was probably only exceeded in crudeness by the character of the machinery provided. We find a history of partial plowing, dodging of stumps, planting in

mud, cultivating in rain, and gathering a scanty harvest out of a wilderness of weeds. The chemical data tabulated by Mr. Maxwell show without further comment the character of the crop produced. It is gratifying, however, to note that on many farms adjacent to the plantation of the Virginia company crops of sorghum were produced which in some instances with careful manufacture would have yielded a fair return of sugar. Yet it is scarcely probable that the soil and climate described by the report will be able to compete with the broad and fertile fields and genial suns of central southern Kansas and northern central Indian Territory and Oklahoma.

MANUFACTURING EXPERIMENTS AT KENNER.

The manufacturing experiments at Kenner were conducted on a small scale and are to be considered rather as the completion of the culture experiments than an attempt to produce sugar economically. The percentage of sugar in the cane recovered in the diffusion juice was uniformly high, the sugar left in the waste chips amounting to only about .3 per cent. The fine work of this small battery furnishes a continued demonstration of the merits of this system of diffusion first set forth for sorghum in Bulletin No. 2, and shows its immense superiority even for small workings over the system used at Rio Grande. The capacities of the two batteries are almost the same. Allowing 25 pounds of chips for each cubic foot of space in the Kenner cell, the total capacity of each cell in pounds is 337.5, which is practically the same as the baskets at Rio Grande. When the convenience of heating, the ease of charge and discharge, the saving of energy in moving the diffusion juices instead of the whole system of baskets with their loads of chips are taken into consideration the preference even for a small factory must be accorded to the closed system of diffusion. Another practical point is of importance. In the experiments at Kenner considerable quantities of sugar were obtained from canes quite as poor as those worked at Rio Grande, and which by the system there used gave no sugar whatever. This fact, however, was not needed to demonstrate the danger of working cane juices for sugar without neutralizing their natural acids and by evaporating them to sirup in open pans. The work at Kenner shows that, by careful treatment and proper technical and chemical control, sugar can often be made from juices of an almost hopeless poverty.

The danger of allowing sorghum canes to remain exposed to hot suns after cutting has long been recognized. Some of the manufacturing data at Kenner would seem to indicate that the danger has been magnified. The cane shipped from the plantation of Mr. Maxwell may be taken as an illustration of this. After nearly a week of exposure it was found to have suffered but little inversion. It may be, however, that the cane was exposed in a pile of considerable magnitude, and in such cases the interior canes are protected. Again it must not be forgotten that these canes suffered such injury in passing through the battery as

to render them practically unfit for sugar making. The general result of the work at Kenner in respect of the inversion of sorghum cane forms no certain evidence of immunity from danger by omitting to deliver sorghum cane at the factory directly after it is harvested. Perhaps a delay of twenty-four hours may be contemplated without alarm, but a greater certainty of a large sugar product will attend the direct transfer of the cane from the field to the factory. The difficulty of purging sorghum massecuite in the centrifugals is not one peculiar to Louisiana, through it perhaps exists there in a greater degree than in Kansas. Uniformly canes poor in sucrose and of low purity furnish a massecuite difficult to dry. This defect is one of great annoyance to the manufacturer, who is obliged to supply his factory with a centrifugal surface out of all proportion to the yield of sugar. The observation of Dr. Stubbs, however, is doubtless correct that sorghum grown in a warmer climate develops a greater quantity of gums and affords a massecuite of a more refractory nature. Sorghum grown in high northern latitudes appears to have a higher purity than that grown farther south, and experience must decide how far purity of juice must be sacrificed to length of season.

In point of fact the difference in seasons between central southern Kansas and northern Louisiana is so slight as to lead to the belief that the sorghum sugar industry might be profitably introduced in the latter locality.

Both the culture and manufacturing results obtained at Kenner from sorghum canes grown in the sugar-cane belt confirm my previously expressed opinion that a soil and climate suitable to the production of sugar-cane are poorly adapted to the production of sorghum sugar. (Bulletin 20, p. 11.)

The low tonnage and refractory nature of the sorghum heretofore produced on sugar-cane lands afford no reasonable hope of an economical supplementary or preliminary season of sorghum in cane sugar factories.

It must also be noted that if the drying of the sugar is to be attended with difficulties described in the Kenner report, all hope of establishing the industry even in northern Louisiana must be abandoned. It seems reasonable to suppose, however, that with a large strike-pan permitting the building of a larger crystal the delay in drying the sugar can be very much reduced.

In the light of these experiments made on a small scale, it would be rash to invest capital in northern Louisiana in a sorghum sugar factory. Future experiments, however, may be able to show more favorable data.

CULTURE EXPERIMENTS IN LOUISIANA.

The general results of the culture experiments carried on in Louisiana corroborate the data obtained at Sterling in respect of the generally valueless character of the new varieties of sorghum. The best results in

general are shown with the standard varieties which have been chiefly cultivated during the past few years. There are, however, some notable exceptions to the rule both as regards time of maturity and sugar content.

While, therefore, most of the work in testing new varieties is of a nugatory character, there have been obtained in particular cases results which justify the wisdom of extensive trials. A notable example of this is shown in No. 6 of the varieties grown at the Baton Rouge station, described as No. 39 from South Africa, and which gave a juice having the following composition:

Total solids (Brix) 19.7 per cent.; sucrose, 15.6 per cent.; glucose, 1.28 per cent.

A single seed head from such a variety would furnish seed in the third year to plant cane extensively, and could the juice from such cane be worked as well as sugar cane juice, it must yield easily 200 pounds sugar per ton. The culture experiments at Baton Rouge were in some respects the most interesting of all those conducted in Louisiana. The seeds planted at the station were grown by the Department last year at Sterling and it was hoped to secure a large number of comparative trials with them in different parts of the country. The misfortunes which attended these trials at Rio Grande, Morrisville, and Conway Springs have been noted.

The observation made by Dr. Stubbs in respect of the value of the Links' Hybrid variety is corroborated by experience in Kansas and other places. Practically the several varieties of sorghum known as Orange with its nearly related subvarieties have been found to be the most valuable for sugar-making purposes, but the analyses given in the report would certainly justify the preference given to the Links' Hybrid in comparison with several other varieties, but practical trials must be awaited before a final decision can be reached.

The improvement in existing varieties which may be secured by the methods inaugurated in our culture experiments and carried out on the lines of investigation marked out will certainly lead not only to the permanent development of canes with higher sucrose co-efficients and lower glucose ratios, but also with lower content of starch, amylo-dextrines and gums, and other bodies interfering with successful manufacture.

MANUFACTURING EXPERIMENTS AT CONWAY SPRINGS.

The first and most radical mistake made by the management was in attempting to remodel the old factory. The first factory was a striking illustration of the surprising degree of unfitness of means to ends which can be secured by insufficient capital, assisted with lack of mechanical training, deficiency in engineering skill, and dearth of time for preparation. Industry, ability in other directions, and deep enthusiasm for the work could not offset the deficiency.

After the expenditure of nearly or quite \$30,000, however, it was shown by the season's work that the new factory was little if any superior to the first. The meager record of but little over 4,000 tons of cane worked during a long and favorable season is a true but complete story of almost total inefficiency. During all this time, as Mr. von Schweinitz has set forth, the expenses connected with the work were quite or nearly as great as if the factory had been working up to its full estimated capacity.

In a dispassionate review of the manufacturing work of the place it seems to me patent that could the factory have worked regularly 200 tons of cane per day, the end of the season would have disclosed a handsome profit. It certainly is not unreasonable to ask for a factory which can do this the season through. Yet it must be confessed that the sorghum sugar industry has never had the help of such a factory. It has never had a fair chance from a merely mechanical point of view. One source of weakness at Conway Springs deserves more than a passing notice, viz., the insufficiency of the water supply. This was one of the greatest difficulties besetting the first season's work as has already been noticed in Bulletin 20. Within a mile of the spot where the factory was built is a stream of good water which would have proved abundant for even a much larger factory; yet both old and new factory were built without considering the absolute necessity of abundant water. A wise capitalist, seeking a safe investment for his money, had he decided on building a sorghum factory would have located it on the banks of the stream. But the town of Conway Springs voted public bonds ostensibly to build water-works, but in reality as a bonus to the sugar company. Therefore the factory was built rather to secure the bonds than to make sure of an abundant supply of water. As a result the town has been supplied with a saturated solution of gypsum masquerading under the name of water and a bewildering agglomeration of tanks, pulleys, pumps, and débris has been operating as a sugar factory. Such will continue to be the history of bonded sugar-houses built without design and operated without aim.

These strictures, apparently severe, are not made in any personal sense. The promoters and builders of the factory doubtless acted in accordance with the dictates of their judgment, and there is no question of their honesty of purpose. It was simply impossible to build and operate a sugar factory under such auspices, and it would have been the part of wisdom to have refrained altogether from the attempt. The record of the chemical control of manufacture at Conway Springs is of the highest interest. Again as last year the cane crop at Conway Springs was the best suited to sugar-making of any in the country. The mean percentage of sucrose in the juice of the chips entering the two batteries for the present season was 11.98 against 12.42 for the preceding season. The per cent. of fiber in the chips was 11.49, giving a juice percentage of 88.51. The total juice in the cane was therefore 1770.2

pounds per ton, and the quantity of pure sucrose 231.1 pounds per ton. Especially encouraging are the results of the trial run in the four days mentioned in the report during which the machinery worked fairly well, averaging 150 tons of cane per day. During this time it was clearly demonstrated that a fair profit could be made, selling first sugars at 6 cents per pound and molasses at 10 cents per gallon. The achievement of four days may easily be made the history of a whole season, and even with better results. In such a soil and climate, and with such a factory as abundant capital and proper skill might supply, the sorghum sugar industry might flourish without the aid of the State bounty. When we take into consideration the burdens with which the season was commenced, the inexperience of the managers, the crampings of insufficient capital, the internal dissensions of the company, the shortness of the water supply, and the defects of the machinery it must be confessed that the company has made a good showing and deserves praise for its heroic struggles. Its record of two seasons has shown to intending inventors the best sorghum-cane region in the State or the country, and there is abundant water in the county by which to build a first-class factory.

CULTURE EXPERIMENTS AT CONWAY SPRINGS.

The slight decrease in the percentage of sucrose in the juice of the canes of Conway Springs as compared with the season of 1888 is probably due to the cause assigned by Mr. Von Schweinitz, viz, a better season for growth, producing a much larger tonnage and juicier canes.

It was gratifying to note that the total substances, not sucrose, in the juice decreased in a somewhat greater proportion than the sucrose, thus securing a slight gain in purity. It will be interesting, however, to watch the sucrose content of the cane for several seasons to see if it continue to show the same high qualities. The special plot culture experiments were made subsidiary to the regular crop work, and hence were rendered valueless for comparative purposes. The mixed character of the canes growing on these experimental plots was another illustration of the danger of planting seeds taken from a whole plot and from canes grown from unselected seeds. The value, however, of even a partial beginning in scientific seed selection is shown by the history given of the amber cane. Not only Conway Springs, but also Attica and Medicine Lodge, were benefited by this selection. The high sucrose co-efficient obtained at Conway Springs during two successive years marks this locality one of the best yet discovered for sorghum growing. Within a radius of ten miles from the village thousands of acres of land could be planted to cane, and a stream of considerable magnitude flowing through the center of this area would supply the water required by several factories. The methods of cultivation employed are of the simplest kind. It is reasonable to suppose that with deeper plowing or subsoiling the crop would be more successfully brought through a very dry

season, and that a more careful cultivation would not only increase the tonnage, but also the sugar co-efficient. The mean content of sucrose in the chips entering the two batteries shows a crop having, over wide areas, a pretty uniform value. The usual violent variations in individual canes, however, are found in the table giving the composition of the juices from single canes. In all cases the purity is based on the total solid matters in the juice as indicated by the Brix spindle. The true purity is really about 10 per cent. higher than this, since it has been shown that the Brix spindle reads some 10 per cent. higher than the actual quantity of solids in solution.

MANUFACTURING EXPERIMENTS AT ATTICA.

The most striking feature of Mr. Carr's report is the statement of losses in manufacture. The next point—probably it should be first—is the old story of imperfect machinery. When the actual working capacity of the factory is compared with the estimates placed upon it by the builders before the manufacturing season opened it will not be a matter of surprise to read of the financial disasters attending its operation. The quantity of field cane which it was designated to work was 250 tons per day. The actual quantity used was less than 100 tons. The crop which the farmers were induced to plant was large enough for the estimated capacity. The delay, worry, and loss from an agricultural point of view, due to deficient capacity, need not be described.

It is strange to note that one of the weakest points in the house was found in the multiple effect vacuum pan. As Mr. Carr justly remarks, this style of apparatus has long since passed the experimental stage. I have noticed a strange tendency among those about to embark in sorghum work to adopt new and untried devices for old and reliable processes. It is true that such processes are very often great improvements on those now in use, but they should never be depended on to save a great financial venture until they have been thoroughly tried. Thus in sorghum factories have been seen diffusion batteries of new design and novel arrangement, pumps of peculiar construction, boilers of unknown possibilities, and evaporating pans heralded only by the unproved claims of their inventors. The readiness with which many, perhaps nearly all, who have devoted themselves to sorghum listen to golden tales of profit, the perversity with which they shut their ears and eyes to the plainest evidence of impending difficulty, the alacrity with which they take into their confidence the boomer of bonds and the maker of machines, are some of the most discouraging features of the industry. It is high time that the era of blind enthusiasm be passed, and it is quite late enough for men to look at sorghum as they do at iron or wheat.

The heating surface required for evaporating sorghum diffusion juice is greater, *caeteris paribus*, than for sugar-cane and beet juices. This

arises from the readiness with which the lime salts and gums coat the copper tubes. In order to secure good results the apparatus should be boiled out every two or three days with soda-lye, and diluted sulphuric acid, or thoroughly scraped. The capacity of the pan should be large enough to permit this necessary cleaning without impeding the regular working of the house. Approved patterns of pan should be used of a kind to avoid loss of sugar in the condensation water, and permitting easy cleaning. A pan which would evaporate 50,000 gallons of pure water in a day might fall far short of evaporating 50,000 gallons of water from diffusion juice.

The great loss of 35 per cent. of the weight of the cane in cleaning is also to be noted. The mean percentage of leaves and seed heads on the total weight of the cane in its maximum maturity is about 25. In a climate like that of Attica, where the lower leaves especially become dry, the weight of leaves and tops for the whole season ought not to be greater than 20 per cent. of the whole. When it is further remembered that much of the crop is worked after frost this number becomes even less. The loss above noted must therefore have arisen from cutting the stems of the seed heads too long or by blowing out the short sections of the cane in the cleaning apparatus. There is no possible excuse for such a loss, since it is not difficult to arrange a cleaning apparatus in which these losses can be avoided. The loss of sugar in the exhausted chips points to some fault in conducting the diffusion which could be easily remedied. The tendency to set the shredding machines to cut larger chips as the season advances is one which should be promptly resisted. The extraction during the first period of work was almost too low for satisfaction, but when the percentage of sucrose in the exhausted chips during the second period was allowed to run up to 1.57 the process became a travesty. During this period also the greatest quantity of cane was worked. Such poor work is calculated to bring discredit on the whole process. The loss of sugar passing into the molasses is largely beyond the control of the fabricant, yet skillful boiling and careful manipulation in the hot room and at the centrifugals will reduce this loss to a minimum. On account of the difficulty with which sorghum massecuite is purged it will be found advisable in my opinion to make the hot room of the factory of large capacity, large enough if possible to hold a week's run, and keep it at from 110° to 120° Fah. The sugar which would pass into the molasses on direct centrifugalling from the strike pan would be largely crystallized and saved by seven days standing in the hot room. The objection to such a course would be the large hot room and great number of sugar wagons required. It resolves itself into a question of economy which can only be answered by experience.

The experiment of filtering the diffusion juice by keeping it at the boiling point with a jet of live steam succeeded beyond all expectation. Mr. Deming deserves great credit for persevering against great diffi-

culties in this matter. The juice evidently suffers considerable dilution by the process and the quantity of foreign matter removed is small. None of the soluble lime salts nor gums that subsequently coat the evaporating tubes and clog the centrifugal sieves is removed by this filtration and it is an open question whether it will prove to be an economical process. Since the only beneficial effect of the steam jet is secured by the rise of temperature, it might be well to inquire, in case filtration should be deemed advisable, whether this might not be secured in some more economical way.

The study of the inversion in the battery forms an interesting chapter of the report. The inversion is naturally computed from the glucose ratios of the fresh chip and diffusion juices. The uniformly mean increase in the glucose ratio may arise from actual inversion of the sucrose during diffusion or to the more ready diffusibility of the reducing sugar. These sugars, however, being less crystallizable than sucrose would lead us to suppose that they would not be more diffusible. It is therefore probable that some of the sucrose is inverted during the process of diffusion. On the other hand it is well known that the organic acids, even acetic, act on dilute solutions of sucrose very slowly, and therefore the total effect in any case must be small. The additional fact that even when the diffusion juices are made neutral by the continuous addition of lime, the glucose ratio is often increased tends to show that sucrose in presence of the lime salts, reducing sugars, nitrogenous bodies and ferments in the juice may be slightly inverted during diffusion. In the Attica experiments it appears that the invertive effect occurs most actively with unripe canes, as is shown by the data from the September run. The inversion which occurred during the other two periods of work was of little importance from a commercial point of view. With the use of a finer chip and a more rapid operation of the battery it would be possible to reduce this inversion to a minimum. The mean temperature of the inner cells of the battery at Attica was about 65°. C and the mean time each charge was under pressure in regular work about two hours. The numerous delays, due to imperfect machinery and insufficient evaporating surface, unavoidably prolonged the time of pressure, but in such an irregular way as to prevent any accurate study of the effects produced. The purity of the diffusion juice is somewhat higher than that of the chip juices, showing that, notwithstanding the increased glucose ratio, a more than compensating quality of other substances was left in the exhausted chip. This was probably due to the low temperature in the battery. This purity, increased by the percentage necessary to correct for the actual solids present in solution, is a very encouraging number. The fact that with such a purity and with good filtration so poor a yield of sugar per ton was secured lends additional emphasis to the statements of the great losses suffered during the course of manufacture. The careful manner in which Mr. Carr has located these losses is worthy of

especial commendation, and shows in a most striking manner the value of chemical control. In the statement of cost of manufacture the fixed charges for taxes, insurance, interest on investment, and wear and tear of factory are omitted, as was also the case with the statement for Conway Springs.

When these charges are taken into consideration the apparent profit in the one case vanishes, and the cost of the sugar per pound in the other is materially increased.

CULTURE EXPERIMENT AT ATTICA.

About 10 acres of land were set apart for special culture experiments and attention to these plots was assured by employing special labor to take charge of it. In this way careful culture of the plots was secured. The seed derived from the Sterling station, as in the other cases, was found to be somewhat mixed.

In the general work some additional data of great value from an agricultural point of view were obtained. The composition of the juice from the samples of different chips for September showed 9.75 per cent. sucrose, 2.29 per cent. reducing sugars, and 15.96 per cent. total solid matter in solution. This matter, as is also the case in all the tables, was determined by the Brix spindle and is about 10 per cent. too high. Although Mr. Carr states that much of the cane worked during the period was immature, yet the mean results of the analyses show by no means a poor character of cane. With careful manufacture from 70 to 90 pounds first and second sugars should have been obtained. The difference between the data collected at the beginning and end of the period do not show any notable increase in value of juice by reason of the greater maturity of the cane. The percentage of fiber in the cane is quite constant. The second period shows the cane at its maximum content of sugar and establishes the fact, important alike from a culture and manufacturing aspect, that October is the month during which the factory should work up to its maximum capacity in that locality. These data, taken in connection with previous experience in Kansas, indicate that the best season for manufacture is from September 15 to November 15. With a factory fully equipped this would give about fifty days of work, and at 250 tons of field cane per day provide for a crop of 12,500 tons of cane, which ought to be raised on 1,000 acres. The folly of planting 2,000 acres for a factory of less than half the capacity mentioned is at once apparent. It is far better for the farmer to plant less breadth and secure a better crop, than to plant a greater breadth and sacrifice the quality and quantity of cane per acre. Sorghum cane for sugar making can not be successfully grown in the hap-hazard manner which has so long been in vogue in the maize fields of the country. For a time, at least, on the fertile farms of Kansas careful preparation of the soil, timely planting, and thorough cultivation by plow and hoe will suffice. But the time will soon come with sorghum when, as with

other sugar plants, the problem of fertilization must be studied both in the field and in the experimental plot. Farmers should not, therefore, expect good returns without careful study of the agricultural problems which the proper growing of sorghum presents.

MANUFACTURING OPERATIONS AT MEDICINE LODGE.

The general character of the factory at Medicine Lodge, as in the other cases, will be found in the reports of Messrs. Cook and Spencer.

In the case of this factory it is a matter of congratulation to be able to say that it was located with due regard to the supply of water and that this water was of good quality. Not only was there an abundance of water for all manufacturing purposes, but on account of the failure of the apparatus to remove the exhausted chips successfully and economically a stream of water was used under the battery to carry off the chips as they were dropped from the cells.

The delays incident to the operating of new machinery were not escaped by the Medicine Lodge Company, and the factory, as in the other cases, fell far short of its estimated capacity. One of the chief delays was caused by the failure of the Yaryan multiple effect pan to evaporate the diffusion juices with sufficient rapidity. This failure was due to the coating of the tubes which necessitated frequent cleaning, the whole factory having to be stopped for this purpose. The experience at Medicine Lodge was that of other places in respect of this point and shows beyond doubt the necessity of providing a larger evaporating surface for sorghum juices in proportion to the amount thereof than for either sugar-cane or beets. In fact, the difficulty of keeping the multiple effect pans clean has been so pronounced that it seems a wise thing to advise the erection of this part of the apparatus in duplicate, so that one set of evaporating apparatus can be in use while the other is cleaning. It might be possible to arrange the pumps of the apparatus in such a way that one system of pumping would be sufficient for the duplicate apparatus, and thus the expense of the additional plant would be confined to the direct cost of the evaporating apparatus itself.

The results of the season's work come more nearly showing a profit on manufacture when all legitimate charges are allowed for than in any other factory where the details of manufacture have been reported to this Department; nevertheless when proper allowance is made for interest on investment, wear and tear, taxes and insurance, it is seen that the factory was operated at a loss.

As a result of the delays noted above and of the late date at which the operations were commenced, it was found impossible to work the whole of the crop, only about 1,000 acres of cane having been delivered when the factory was closed. It is but fair to say that if the amount of second sugar obtained should be equal to that claimed in the report just quoted it will show probably a direct profit of a small amount to the factory for the season's work, excluding the charges above noted.

If, however, the whole of the crop could have been worked promptly, it is evident that a very handsome profit would have been realized. This is encouraging to the sorghum-sugar industry and is the most positive evidence of economical success that has yet been obtained.

The mean composition of the canes entering the battery, as obtained from a table of analyses prepared by Mr. Sanborn from the work of himself and Mr. Edson, is as follows:

	Per cent.
Sucrose	10.44
Glucose	2.24
Purity	63.66

With good manufacturing work under favorable conditions, the canes of the above composition should have yielded 100 pounds of first and second sugars per ton. The amount of the first sugar made, according to the report of the 1st of January, per ton of field cane was 54 pounds. On the estimated yield of second sugars the total yield of sugar per ton of field cane was nearly 75 pounds. Allowing for the usual percentage of waste in cleaning the cane, it is seen that the actual yield per ton of clean cane agrees fairly well with the theoretical yield which should be obtained.

It is also encouraging to note that this fair financial success was obtained with cane which was considerably inferior to that employed for manufacture both at Conway Springs and Attica. With more careful culture developing a higher grade of cane it is reasonable to expect hereafter a fair economical success of the work at Medicine Lodge.

CULTURE EXPERIMENTS AT MEDICINE LODGE.

The miscellaneous analyses of small samples of cane and single canes received at the factory at Medicine Lodge show the same wide variation in the percentage of sucrose that has always been observed in similar experiments elsewhere. These miscellaneous analyses have been collected by Mr. Sanborn into one large table beginning with analyses on the 21st of August. Even at this early date the Early Amber cane at Medicine Lodge showed a high percentage of sucrose and a high purity. This high percentage of sucrose was increased, however, toward the latter part of this month, as will be seen by the numbers indicating the composition of the single canes or small samples of cane during the whole month. This gratifying showing from the Amber cane is particularly noticed, because in some other localities, as indicated in other parts of this report, the Amber cane has been discredited as a sugar-producing plant. It is easy to see from the analyses that had the factory been ready for work at the time mentioned large quantities of sugar could have been made. At the commencement of the analyses of other varieties on the 1st of September, it is seen that the content of sugar was very much lower, the Early Amber variety being uniformly better than the other varieties at that season. Among other varieties tested were those grown from seeds sent by the

Department from the experiment station at Sterling, and which were planted upon sod and without the proper conditions for successful experimental culture. • During September, also, the Early Amber varieties continued to show, in general, the highest percentage of available sugar, although during the latter part of the month there was marked improvement in other varieties in their sugar content. Especially was this true of some of the analyses of Early Orange, which began to show up well after the middle of September. During the latter part of September and in October many samples of Early Orange showed good results, but mixed in with these are many others of Orange and other varieties showing a very poor content of sucrose. The percentage of sugar, however, in the Early Orange and some other varieties kept up well even to the end of the season, analyses as late as the 14th of November showing a content of 12.10 per cent. of sucrose, and a purity of 76.13 in samples of Early Orange cane. In this same table, also, Mr. Sanborn has collected analyses of samples of beets grown at Medicine Lodge which will be of interest by way of comparison with analyses of the sorghum juices.

In order to secure the latest information from the factories in Kansas, the Secretary authorized Mr. W. W. Cook to make a final tour of inspection in accordance with the following instructions:

DECEMBER 16, 1889.

DEAR SIR: I have had the Secretary commission you to serve for one additional month for the purpose of securing some further information for our report, and which you will proceed to obtain in accordance with the following instructions:

You will visit each of the factories having received Government aid during the past year and obtain from the proper authorities the following information:

- (1) The number of tons of cane purchased and whether this cane was topped before or after purchase.
- (2) The total number of tons of cleaned cane chips used in manufacture. If it be claimed in connection with these two items that a part of the cane was worked for molasses only, you will obtain the total number of tons and the respective amounts claimed to have been worked for molasses and sugar.
- (3) The number of pounds of first sugar made and the number of pounds of second sugar made and the number of gallons of molasses obtained.
- (4) The quantity of sugar sold and the price obtained therefor, the quantity of molasses made and the price obtained therefor.
- (5) The amount of seed produced and the price obtained for any that may have been sold.

In addition to this you are directed to obtain from the stockholders of the various factories, in so far as they can be reached, their statement of the profitableness or unprofitableness of the sorghum sugar industry. You will also see prominent farmers who have raised cane for factories and obtain from them like information. You will put this information into writing and read it over to each of the parties interested before sending it as authoritative.

You are especially also directed to visit the factory at Minneola, where the roasting process was practiced, and, in addition to the information above required, to investigate a rumor which has come to us in the newspapers that fraud was practiced by this company, and if so, the extent and character of this fraud. The factories which you will visit under the above instructions are as follows:

Medicine Lodge, Attica, Conway Springs, Minneola, Meade, Arkalon, Liberal, and

Ness City. You are also authorized to visit the factory at Fort Scott, and, so far as possible, secure the information noted for the above factories.

It is especially desirable that this work be completed and forwarded to me by the middle of January, the time at which your present commission will expire.

I received this morning your report on the beet-sugar experiment at Medicine Lodge, and I am greatly gratified at its favorable termination and desire to thank you for the information sent.

I inclose for your use half a dozen traveling orders, and you will please return those not required.

Respectfully,

W. W. Cook,
Medicine Lodge, Kans.

H. W. WILEY,
Chemist.

In compliance with the above instructions the following reports have been received, comprising the latest information which can be obtained for this bulletin:

NESS CITY, KANS., *January 2, 1890.*

DEAR SIR: In my investigation of the sugar works at this place I find as follows:

Cost of buildings	\$11,716.89
Cost of machinery, including the skilled labor in erecting	98,500.00
Cost of common labor in erecting machinery	1,453.30
Quantity cane bought	tons.. 749
Total amount paid for cane	\$1,498.00
Amount paid for labor while running	\$992.00
Total cash paid for fuel during season	\$836.00
Quantity without tops worked	tons.. 716
Quantity seeds and tops	do.. 33
Amount received for seeds and tops, at \$2 per ton	\$66.00
Total amount molasses made (about)	gals.. 7,000
Total amount molasses sold (about 300 gallons)	\$63.17
Estimated value molasses on hand (6,700 gallons)	1,005.00

A part of the cane was topped by farmers before hauling in and the tops not delivered, and a part was topped while on the wagons (by the use of hay-knives) after it was hauled to factory, and these tops were sold without thrashing at \$2 per ton as given above.

Owing to the excessive dry weather, and cane not maturing, they failed to make any sugar. They only ran about nine days. Their contract with the Kilby Manufacturing Company, of Cleveland, Ohio, was to have the factory ready to run by September 1, but it was not finished until October 1, and owing to this failure on the part of the Kilby Manufacturing Company there is some trouble in making final settlement. According to contract price there is still due the Kilby Manufacturing Company \$38,000. They are now negotiating propositions for a compromise, and they think the prospects good that it will be effected. In addition to the above the sugar company is owing about \$4,000, a part of it for cane and labor. But they claim they are holding this back in order to help in getting \$15,000 in bonds from our township which voted the bonds, but the township officers are refusing to sign the bonds.

There is an unsettled feeling among the farmers regarding raising cane next season; some have plowed in preparation for raising cane, and others are holding off. But if the sugar company pay the bills now due for cane and labor I think the farmers will be satisfied and be ready to try raising another crop. It is the opinion generally that the raising of cane here is a comparatively certain crop. I had a talk with Mr. Calhoun, who has no financial interest in the sugar business, but is president of the

State bank of Ness City. He has been in this country for eleven years, and he says this year is the only failure in the crop of sorghum-cane he has seen since he has been here.

The proprietors of the works here that I have talked with seem quite confident of the financial success of the sorghum-sugar industry, but say it may not sound very well, considering the failure they have made; but that is their conviction. They claim they were well aware they would lose money every day they ran, but they wanted to test the machinery, satisfy the farmers, and try and get the \$15,000 township bonds that were being held back.

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY, *Chemist, Department of Agriculture,*
Washington, D. C.

MEAD, KANS., *January 6, 1890.*

DEAR SIR: The headquarters of the Southwestern Sugar Company, owning the works at Liberal, Arkalon, and this place, is located at this place, and I have visited the works at the other places and seen some of the farmers and secured as much information as I could, and figures from the book-keeper and president here, giving the figures of the three factories in this report, are as follows:

	Mead.	Arkalon.	Liberal.
Quantity of cane worked.....tons..	384	202	601
Quantity of sugar made (estimated).....pounds..	6,000	4,000	10,000
Quantity of molasses made (estimated).....gallons..	3,750	3,750	7,500
Quantity of seed (estimated).....bushels..	600	400	701
Quantity of clean chips worked (estimated).....tons..	238	126	425
Cost of machinery and erection.....	\$50,524.10	\$49,466.75	\$50,693.04
Cost of buildings and erection.....	13,252.71	10,949.49	
Cost of buildings.....			12,916.50
Cash paid for cane.....	576.79	303.58	902.56
Cost of fuel for season (estimated).....	400.00	300.00	600.00
Cost of labor while running.....	435.00	261.00	609.00
Amount of sugar sold (received).....	*75.00	*75.00	†210.00
Value of sugar on hand (estimated).....	210.00	140.00	315.00
Value of molasses on hand (estimated).....	700.00	700.00	1,500.00

* 1,000 pounds.

† 3,000 pounds.

Estimated value of seed, 15 cents per bushel.

The tops were cut off at cutter of mills. The proprietors of these factories were well aware that they would ran at a heavy loss, but ran in order to test and adjust machinery and to satisfy the farmers to some extent. There is some dissatisfaction with the farmers, they claiming there would have been more merchantable cane if they had been ready to commence work sooner. The mills did not commence work until about the 1st of October, and ran about two weeks at Mead and Liberal and about one week at Arkalon. At Liberal and Arkalon they are offering the farmers in payment for the cane not worked one ton of coal and one barrel of molasses for every 15 acres of cane. Most of the farmers are accepting this, but a few are holding off. The company have paid for all labor and cane worked at all these factories, but are still owing on machinery about \$29,000 and other bills about \$3,000. The farmers are satisfied to go ahead and raise cane another year if they can have some assurance that the factories will be run. The company here is in a rather demoralized condition, but Mr. Heber, who is president of the sugar company and also president of the Mead County Bank, thinks he will succeed in getting it on its feet soon.

Every one in the county connected with the company and outside of it seem to think the sorghum industry is going to be a great success. There was no second sugar made at any of these factories,

You will notice that the sugar sold and estimated value of sugar on hand does not amount to the total made. It is claimed a large amount was carried off in samples.

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY,
Chemist, Washington, D. C.

MEAD, KANS., January 7, 1890.

DEAR SIR: I have made as thorough an investigation of the purported fraud practiced by the American Sugar Company, at their works at Minneola, as possible. This company is operating with the Adamson roasting process, and as their headquarters are at this place and the officers and parties that were engaged in working up the bonds are most of them living here, I have done most of my work and investigations at this place. The officers of the American Sugar Company sent to Dodge City and bought two barrels of sugar and mixed into their sirup (by advice, as they claimed, of their sugar-boiler) in order to start it to graining, and it was brought in and mixed during the night-time, for the reason (as they claimed) that they had enemies to their process who would use it against them if it was done publicly and by daylight, and about October 26, in the presence of quite a number who had been invited to be present, this sugar was thrown out, claiming to have been made by their process and from cane grown in that section. A short time previous to the time this sugar was thrown out one Willis G. Emerson, residing at this place, made a contract with the American Sugar Company for certain territory to work, and secure bonds to the amount of \$15,000 on each township, in consideration of which the American Sugar Company were to erect a sugar factory of the Adamson roasting process. The contract made with Mr. Emerson was that he should furnish his own assistance and pay all expenses incurred in the work and receive as his compensation a certain per cent. on all bonds he secured. Before entering upon his work, and before the day the sugar was made at Minneola, I am told by good authority (and may have an affidavit to inclose in this to that effect) that Mr. Emerson had said he wanted sugar if they had to haul it to factory. Mr. Emerson employed some six or eight persons to assist him, and armed with this sugar (made at Minneola by the Adamson roasting process), as samples showing what the process would do, started out to work filling township scrip for some imaginary debt and calling elections to take up the scrip by issuing refunding bonds. Everything seemed to be getting along finely. The people out here, where they had failure of crops and times were hard, seemed willing and eager to accept anything that would seem to offer relief. They had succeeded in securing the bonds from four townships in this (Mead) county, and two townships in Ford County, and were calling elections in large numbers of other townships when the illegal manner in which they were obtaining the bonds was beginning to be agitated by some, and some newspaper comments had been made upon it, and in one township the party holding the scrip had been compelled by drawn fire-arms to surrender the scrip, and there being some little quiet talk about the manner in which sugar had been obtained, Mr. Emerson came in and demanded of the officers of the American Sugar Company that they pay to him the amount of money he had expended, claiming it to be \$4,200. This they refused to do, and he (Emerson) rushed into print, exposing the manner the sugar was made, claiming he had just found it out and wished to protect the people. It seems to my mind the fact of their intending to vote bonds upon about one hundred different townships, and agreeing to build as many sugar factories is as much evidence of fraud as anything that has been done. I have secured what affidavits and evidence I could and inclose them in this. I do not think there is any question but the American Sugar Company and those working for them have practiced a deception upon the people and

it is a great injury to the sugar industry at large. And it would seem too bad that those trying in good faith to build up the industry should suffer thereby. The bonds issued and delivered as mentioned before, viz, the bonds from four townships, are held by the bank here, and those from two townships are back east. The townships so far have been unable to get them back. Can not say what will be done with them. All further operations were promptly suspended when the matter became known to the public.

Yours very truly,

W. W. Cook.

Prof. H. W. WILEY,

Chemist Department of Agriculture, Washington, D. C.

HUTCHINSON, KANS., January 8, 1890.

DEAR SIR: The president and book-keeper of the American Sugar Company have furnished the following figures regarding their factory at Minneola, Kans., to wit:

Cost of machinery	\$18,658.00
Cost of buildings.....	\$12,000.00
Cost of erecting machinery and buildings.....	\$4,136.19
Quantity of cane worked.....tons..	469
Cash paid for cane	\$727.99
Cost of fuel for season	\$233.16
Cost of labor while running	\$1,353.20
Quantity of sugar made (about)	pounds.. 2,000
Quantity of molasses made (about).....	gallons.. 4,664
Quantity of seed (about)	tons.. 87
Value molasses on hand (estimated)	\$900.00
Value seed (estimated).....	\$250.00

A very small amount of sugar is on hand; it is claimed it has been carried off in samples.

I go from here to Fort Scott.

Yours very truly,

W. W. Cook.

Prof. H. W. WILEY,

Chemist Department of Agriculture, Washington, D. C.

FORT SCOTT, KANS., January 10, 1890.

DEAR SIR: In regard to the sugar factory at this place I find as follows for the season of 1889:

Quantity of cane worked.....tons..	7,113
Amount paid for cane	\$14,226.00
Cost of fuel for season	\$1,473.83
Cost of labor for season	\$7,834.68
Quantity of sugar made	pounds.. 358,840
Quantity of molasses made (estimated)	gallons.. 100,000
Quantity of seeds in tops.....	tons.. 675
Estimated value sugar product at 5½ cents.....	\$19,736.20
Estimated value molasses product	\$10,000.00
Estimated value seed product	\$1,350.00

They have about 800 barrels of sugar on hand, not sold, and they estimate their entire product at $5\frac{1}{2}$ cents per pound, and the molasses at 10 cents per gallon.

They have sold some of the molasses, and it has netted them that amount. They have the seed on hand in the tops, and they estimate it at \$2 per ton. The tops were cut off by farmers and brought to factory separate, and after cane was delivered. The factory here commenced work August 28 and made one day's run entirely into sirup, and they ran about sixty days and worked up all the good cane they had. A part of the cane was planted upon the creek bottom, and overflowed two or three times during the summer and cut their crop short. It was a wet, cold, and backward spring, and the cane nearly a month later than usual in maturing.

Mr. J. C. Hart, the chemist and superintendent, is confined to his room with influenza, and I could not see him. Mr. Eli Kearns, the treasurer of the company, who has given his time in active work in the business during the past season, says heretofore he has been somewhat undecided as to the ultimate financial success of the industry, but says now he believes it will get on to its feet and be one of the greatest industries of Kansas, especially if the growing and manufacture of beets can be combined with cane. Mr. C. F. Drake, the president of the company, says he has had confidence in the final success of the business and has still more confidence after the past season's work and experience, but thinks there will be many improvements made in the business.

I have not been able to see any farmers at this place, but it is claimed there is no question about it paying the farmers to raise the cane better than any other crop they can raise.

I find the experiment at Medicine Lodge in beets has caused a great interest over the country. At this place they are thinking of raising beets the coming season. They were asking me about it, and I told them there would be an official report on it from the Department of Agriculture soon.

I go from here to Conway Springs.

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY,

Chemist Department of Agriculture, Washington, D. C.

CONWAY SPRINGS, KANS., *January 11, 1890.*

DEAR SIR: In making up a summary report of the sugar works at this place, for the year 1889, I find as follows:

Value of real estate (estimated).....	\$10,000.00
Value of sugar works (estimated).....	\$82,500.00
Quantity of cane worked..... tons..	4,596
Amount cane cost.....	\$6,894.00
Cost of labor for season in working.....	\$12,359.00
Cost of fuel for season.....	\$3,259.00
Cost of cooperage (about).....	\$850.00
Number of men employed night and day.....	80 to 90
Quantity of first sugar made..... pounds..	209,591
Quantity of second sugar made..... do....	57,485
Total quantity sugar made..... do.....	267,076
Total quantity molasses made..... gallons..	58,500
Cane planted (estimated)..... acres..	800
Value sugar product (estimated).....	\$14,689.18
Value molasses (estimated).....	\$5,850.00

At this place the farmers topped the cane and kept the tops, and the sugar company paid \$1.50 per ton for the cane without tops. The sugar company are in a

demoralized state. They stopped working sirups into second sugars the first of the year, after working about 25,000 gallons and having about 35,000 gallons not worked. There is due farmers for cane about \$7,000, and for labor about \$4,300. The latter is secured by indorsing to a trustee the 2 cents per pound as a bounty due from the State.

The Kilby Manufacturing Company, of Cleveland, Ohio, holds the first lien on the sugar factory to the amount of \$25,000, and it seems to be the impression that this company will eventually own the works, and are already making some proposals to the farmers to form a stock company and buy the works, offering to give them liberal time in making payments, and it is not altogether improbable that some such arrangements may be consummated. The farmers are willing to raise cane at \$1.50 per ton, but must have pretty good guaranty in future that they will get paid for it. I had a talk with H. H. Richards, the president of the sugar company, and have seen no one who seems to be as enthusiastic as he as to the future financial success of the industry. Mr. Osterhouse, the book-keeper and stockholder, says, while the sugar works here has worsted all of them that put any money in it, owing to the bank failing to furnish the money they had promised and bad management, yet, if he had sufficient amount of money, he would engage and invest in the sugar business in preference to any other. Mr. Wilson, who is also connected with these works, also expressed himself as having confidence in the final success of the industry, and all I have met seem to think the same way.

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY,

Chemist Department of Agriculture, Washington, D. C.

MEDICINE LODGE, KANS., *January 14, 1890.*

DEAR SIR: I have just returned from Attica, and have to report upon them the sugar factory at Attica for the season's work of 1889 as follows:

Cost of machinery	\$52,747.21
Cost of buildings and erecting machinery	\$33,775.74
Quantity of field cane worked	tons.. 7,082
Amount paid and due for cane	\$10,566.76
Amount of cane furnished on stock	\$3,597.35
Cost of fuel for season	\$3,387.02
Cost of labor while running	\$10,555.14
Cost of cooperage	\$2,044.74
Cost of incidentals	\$845.85
Salaries paid while running	\$2,406.17
Lubricating	\$370.08
Quantity first sugar made	pounds.. 256,481
Quantity second sugar made	do.... 41,000
Total quantity sugar made	297,481
Quantity molasses made (estimated)	gallons.. 60,000
Sugar sold, 203,000 (amount received)	\$11,148.56
Molasses, sold 4,573 gallons (amount received)	\$352.44
Value sugar on hand, 91,481 pounds, at 5 cents per pound (estimated) ...	\$4,724.05
Value molasses on hand (estimated)	\$5,542.70
Number of men employed day and night	66 to 116

Commenced work August 26, and stopped cutting cane November 12.

At this factory they bought cane with tops on and paid \$2 per ton, and 50 cents on each ton was applied as stock. The tops were cut off at cutter and used as fuel. These works, as I wrote you before, went into the hands of a receiver with liabilities

of about \$59,000. They estimate there will be about 80,000 pounds more of second sugars when they get the molasses all worked over. They have spent a considerable time in fixing their hot room, and have not worked more than a third of their sirup over.

Mr. J. S. Jobes, president of the Attica State bank, and the receiver of the sugar works, says he is confident of the success of the sugar industry. He says he thinks these conditions will cover it, viz :

Experience in the business, plenty of capital, and first-class business management. I talked with several farmers; they say they are willing to raise the cane at \$1.50 per ton if they can get pay for it, as that will pay them better than any other crop they can raise.

I should have stated in the figures giving the cost of buildings and machinery is included the cost of the city water-works, amounting to \$8,385.

Yours very truly,

W. W. Cook.

Prof. H. W. WILEY,

Chemist Department of Agriculture, Washington, D. C.

MEDICINE LODGE, KANS., *January 15, 1890.*

DEAR SIR: I herewith submit to you my summary report of the sugar factory at this place for the season of 1889, which is as follows:

Cost of buildings.....	\$18,983.38
Cost of machinery and erection of the same	\$73,324.00
Quantity of field cane worked	tons.. 7,363
Cash paid for cane	\$7,536.33
Amount donated in cane	\$5,984.28
Amount paid for fuel	\$7,539.41
Cost of labor while working.....	\$6,594.46
Cost of salaries while working.....	\$980.00
Entire cost of cooperage	\$1,370.67
Incidentals while working	\$459.26
Lubricating and oils	\$145.00
Number of men employed, including day and night.....	60
Quantity of first sugar made	pounds.. 330,251
Quantity of second sugar made to date	do.. 111,987
Quantity sugar to date	do.. 442,238
Quantity of molasses for season	gallons .. 79,380
Quantity of hand-picked selected seed.....	bushels.. 1,200
Quantity of second sugars yet to make (estimated).....	pounds.. 60,000
Quantity of common seed thrashed.....	bushels.. 8,800
Amount of sugar sold, 313,916 pounds (amount received)	\$17,047.17
Amount of sugar on hand, 128,322 pounds (estimated)	\$7,057.71
Estimated value molasses, 8 cents per gallon.....	\$6,350.40
Estimated value 1,200 bushels select seed.....	\$1,500.00
Estimated value 8,800 bushels common seed, at 15 cents.....	\$1,320.00

Messrs. Eldred and Hinman, the proprietors of the works here, had the farmers top the cane in the fields and haul it in afterwards, but all of the seed was never delivered. They have coal enough on hand (that is included in the above figures) to work over the balance of the second sugars, and all other labor and expenses are figured up to the present time and they figure the balance of labor and expense in working over the balance of the molasses will be about \$450; so in summing up their season's work, and taking inventory of stock and cost and expenses from the time

they commenced working cane until they finished working molasses into second sugars, shows as follows :

Value of sugar sold	\$17, 047. 17	
Value of sugar on hand	7, 057. 71	
Value of sugar to make	3, 300. 00	
Value of molasses	6, 350. 40	
Value of 1, 200 bushels select seed	1, 500. 00	
Value of 8, 800 bushels common seed	1, 320. 00	
Two cents per pound, bounty paid by State	8, 004. 76	
		\$44 580. 04
Cash paid for cane	7, 536. 33	
Amount of cane donated	5, 984. 28	
Cost of fuel	7, 539. 41	
Cost of labor while working	6, 594. 46	
Cost of salaries while working	980. 00	
Cost of cooperage	1, 370. 67	
Incidentals while working	459. 00	
Lubricating and oils	145. 00	
Estimated cost in working balance sugars	450. 00	
		31, 059. 41
Profit of season's work		13, 520. 63

This factory did not commence work until September 9, which was over a month after cane was matured, and stopped cutting cane November 11, making sixty-two days, and about one week of that time it was so wet that farmers could not haul cane out of the field and they were subjected to delays in adjusting machinery that would be incident in starting any new works having as much machinery as a sugar factory. Considering these delays, and the fact that nearly all the men were entirely inexperienced and had never worked in a sugar factory before, this company has fully demonstrated that if the conditions necessary to success are complied with the manufacture of sugar in Kansas is going to be a grand success, and more especially when it is taken into consideration (as demonstrated by the recent experiment made at this factory) that beets can be raised and made into sugar successfully as well as sorghum cane, forming a combination that no other country is favored with and lengthening the season of actual work in manufacturing to at least six months in the year.

I would mention the following conditions necessary to exist in order to success:

A location where there is an abundant supply of good water, at least 1,000,000 gallons every twenty-four hours.

The best of machinery, constructed and arranged with a view of economy in labor.

Experienced workmen, plenty of money, and good business management :

A majority of the factories in the State have been unfortunate during the past year (and if a dividend has not been declared I well understand how difficult it is for the public to accept any reasons for it), the causes of which are easily explained and well understood by parties familiar with them, as follows: The cane grown at the five sugar factories located in the western part of the State did not mature sufficiently to make sugar, owing to a scarcity of rain in that section of the State, the oldest inhabitants claiming that it is the first year they have ever known sorghum cane fail to mature, and other factories have had an insufficient supply of water, defective machinery, a limited amount of capital, and poor business management. I think in the future one of the greatest drawbacks to the industry is going to be in parties securing subsidies and undertaking the business without due regard to the conditions necessary to success.

I feel that Messrs. Eldred and Hinman deserve a great deal of credit, for they have worked untiringly and spent their time and money to make the business a success, not only for the benefit of themselves, but for the good of the country at large.

They have kept everything with a system, and are ready and willing to give the public the benefit of any knowledge or experience they may have obtained. There are some improvements, which are minor compared to the entire works, which Messrs. Eldred and Hinman are contemplating making before the commencement of this year's work, and some other improvements they are desirous of making which are of more importance and somewhat expensive, to wit, to enlarge their storage and hot room and supply it with additional tanks so as to reboil the molasses and store it in the hot room preparatory to graining and throw out the sugar at the same time they are making first sugars, thereby saving the additional expense of working over molasses into second sugars after the factory has stopped cutting cane. They also desire to put in bone-black filters to filter the juice, and put in a refinery in a small way to refine their own product; also to put in vats for washing beets, cutter to cut them, and more defecators and appliances for handling the beet juice and utilizing the skimmings and settlings.

I have interviewed Messrs. Eldred and Hinman as to their views regarding the financial success of sugar-making in Kansas, and they claim that it is no longer an experiment, but their work and experience during the last season have fully demonstrated to their minds that if the conditions heretofore mentioned are complied with success is assured. They claim that it requires a large amount of capital to construct and operate, and will be necessary to expend still more in order to secure the best results. They have great confidence in using bone-black filters and refining that they will greatly improve their sugar and make it of an uniform grade and color, and will also improve the quality of the molasses so as to meet a ready sale at more than double the price they are able to obtain now. They feel quite confident they will be able to make 1,500,000 pounds of sorghum sugar alone during the present year, and with the manufacture of beet sugar in connection with sorghum, they say, expect to greatly increase this amount.

I have talked with several of the prominent farmers who raised cane the past year for the sugar factory and they say that even this year the cane paid them much better than any other crop they raised, and they are making calculations on raising both cane and beets the present year.

Col. C. H. Eldred, one of the proprietors of the sugar works, is now feeding about seven hundred head of cattle on grounds adjoining the sugar factory and is mixing one third ground sorghum seed to two thirds corn, and says that he is getting better results than he ever did in feeding corn alone, and if he had a sufficient amount of the sorghum seed he would use it in equal parts of corn. As Mr. Eldred is an experienced feeder of many years, his judgment can be relied upon.

I do not think Congress could make an appropriation with a better prospect of benefiting the people and country at large than to continue aid to this industry, and I do not think it should be done sparingly, but liberally to those who are working in good faith and will use it not only judiciously, but with good judgment for the benefit of the industry and the public good. It may be I am presuming too much in this direction, but I assure you that it is a matter I feel a deep interest in, and if it receives aid and encouragement I confidently believe that within the next few years it will be the leading industry of this section of the country.

In this my last report, and closing my work for the Department of Agriculture, I wish to say my associations with all parties connected with the several sugar factories has been of the most pleasant nature and I have received the most courteous treatment at their hands. And I desire to extend my thanks for the kind treatment and assistance in my work that I have received from the Department of Agriculture. Trusting that I have rendered some assistance to the enterprise, and with best wishes for the future success of the industry, I am

Yours very truly,

W. W. COOK,

Prof. H. W. WILEY,

Chemist Department of Agriculture, Washington, D. C.

SUMMARY OF MANUFACTURING WORK.

A general review of the work of the several factories engaged in sorghum sugar making during the past season is not of an encouraging character. In seven factories the record is total failure. An attempt to locate the causes of these failures has been made in the discussion of the several reports. The only gratification which the Department can derive from a view of these failures is in the fact that they are not wholly chargeable to irremediable defects in the plant producing the sugar, but rather from inattention to the facts demonstrated in our past work and fully set forth in previous reports, especially in Bulletin No. 20. It is scarcely credible that in some of the places where the season's work was attended with failure sites could have been selected and factories built in plain disregard of the absolute conditions of success determined by the Department's work.

Since it is possible that the same errors may be repeated, and the same disasters incurred, it will be well to reproduce the resumé of conditions for success taken from Bulletin 20, pp. 17 *et. seq.*

POINTS TO BE CONSIDERED IN BUILDING A FACTORY.

"It is of the utmost importance, both for the individuals and the industry, that intending investors in the sugar business should carefully consider the problem presented to them in all its forms. Failure is not only a personal calamity, but a public one, in that it deters capital from investment in an industry which, properly pursued, gives promise of a fair interest on the money invested.

"Soil and climate.—The importance of soil and climate has already been discussed. In the light of present experience it must be conceded that a soil and climate similar to those of southern central Kansas are best suited to the culture of sorghum for sugar making purposes. Further investigations may show that Texas and Louisiana present equally as favorable conditions, but this yet awaits demonstration. Conditions approximately similar to those mentioned can doubtless be found in Arkansas, Tennessee, North Carolina, and other localities. The expectations which were entertained and positively advocated a few years ago of the establishment of a successful sorghum industry in the great maize fields of the country must now be definitely abandoned. He who would now advise the building of a sorghum sugar factory in northern Illinois, Indiana, Iowa, or Wisconsin, would either betray his ignorance or his obstinacy. A season of manufacture, reasonably certain for sixty days, is an essential condition to success in the manufacture of sorghum sugar. Early frosts falling on cane still immature, or a freezing temperature on ripe cane followed by warm weather, are alike fatal to a favorable issue of the attempt to make sugar. Sober and careful men will not be misled by the claims of the enthusiast, by the making of a few thousand pounds of sugar in Minnesota,

by the graining of whole barrels of molasses in Iowa. Four or five million acres of land will produce all the sugar this country can consume for many years, and these acres should be located where the climatic conditions are most favorable. During the past season sorghum cane matured as far north as Topeka, but in 1886 the cane crop at Fort Scott was ruined by a heavy frost on the 29th of September, and in 1885 a like misfortune happened at Ottawa, Kans., on the 4th of October. These interesting facts show that these points are on the extreme northern limits of safety for sorghum sugar making, and the region of success will be found to the south and west of them.

“Natural fertility of soil must also be considered as well as favorable climate. The sandy pine lands of North Carolina can not hope to compete with the rich prairies of southwestern Kansas and the Indian Territory. Indeed, in my opinion, the last-named locality, should it ever be opened to white settlers, is destined to be the great center of the sorghum sugar industry; nevertheless, those who plant the virgin soils of this great southwestern empire must remember that to always take and never give will tire the most patient soils, and a just return should be annually made to the willing fields. A judicious fertilization, rotation of crops, and rest, will not only preserve the natural fertility of the fields, but give even a richer return in the improved quality of the cane and the greater tonnage secured. Perhaps the most sensible solution of the problem of the disposition of the waste chips will be found in returning them to the soil. These chips have a positive manurial value in the nitrogen they contain, while their merely physical effect on the soil may prove of the highest importance.

“*Water supply.*—The misfortunes which have attended many attempts in the manufacture of sugar by diffusion, by reason of an imperfect or insufficient water supply, are a sufficient warning on this subject to the careful student. Not only should the water supply be abundant and easily accessible, but that portion of it, at least, which is to be used in the battery should be as pure as possible. The presence of carbonate of lime and some other carbonates in water is not injurious, but the evil effects of a large amount of other kinds of mineral matter are shown in the data from Conway Springs. When the supply of water is insufficient it has been customary to use ponds for receiving the waste from the factory, so that it may be used again. This method is applicable if care be taken to prevent organic matters, scums, etc., from entering the water supply. In case this precaution is not taken the operator of the factory may find himself in the condition in which the Department was placed in its first experiments at Ottawa and Fort Scott, in being compelled to use water foul and putrescent. It is scarcely safe to rely upon a well for a supply of water, especially if it has to be sunk to any depth. Where pumping machinery must be placed many feet below the surface, as in the cramped condition which attends its erection in a well, serious difficulties may arise from the machinery getting out of order, and a great

loss of energy may ensue from the necessity of lifting the water to a great height. In all cases where it is possible a running stream of water should be selected for the supply, and the factory should be placed conveniently near its banks. The importance of this matter is emphasized the more when it is considered that the most favorable localities for sugar making, as indicated by the present state of our knowledge, are situated in regions where the water supply is notably deficient. Yet it must be admitted that even in southern and western Kansas it will not be difficult to find localities for the erection of sugar factories where the water supply is certain and abundant. In the light of past experience it is not probable that any further mistakes will be made in this direction. Careful estimates should be made of the quantity of water required, and absolute certainty should be secured of the supply of that amount of water, and even of a much greater amount in cases of emergency. The only safety will be found in some such plan as this.

“Proximity of cane fields.—Another point which must be taken into consideration in the location of a factory is the distance which the cane is to be transported. This is a matter which of course the farmers raising the cane are more interested in than the proprietors of the factory, when the cane is grown by contract. With good roads, in a level country, it is easy to draw from $1\frac{1}{2}$ to 2 tons of field-cane at each load. The average price which is paid for such cane at the present time is \$2 per ton. It is evident that at a given distance, varying according to the price of teams and labor in each locality, the cost of transportation would equal the total receipts for the cane; in this case the farmer would have nothing left to pay for the raising of the cane and profit. Evidently true economy, from an agricultural point of view, would require the cane to be grown as near the factory as possible. It would be well, indeed, if all the cane could be grown within a radius of 1 mile from the factory. This would give, in round numbers, 2,000 acres tributary to a factory. With an ordinary season this ought to produce 20,000 tons of cane. The lengthening of the radius of this circle by one-half mile would give the greatest distance to be hauled $1\frac{1}{2}$ miles, thus vastly increasing the surface tributary to the central factory. It is true that at the present time farmers are easily found who are willing to draw their cane 4, 5, and even 6 miles, but this condition of affairs can not be continued when the business is fully established and the factories in sharp competition with each other. In case the exhausted chips are to be returned to the soil as fertilizer the importance of a centrally located factory, as described, is doubly emphasized.

“Fuel.—A cheap and abundant supply of fuel is not less important than the raw material to be manufactured into sugar. As far as the sorghum-sugar industry is concerned the coal which is used for fuel is transported almost exclusively by rail. In locating a factory, therefore, both for convenience of shipping the product and for receiving a sup-

ply of fuel, it should be placed sufficiently near a railway line to enable it to be connected therewith by a switch. It is better, however, that the switch should be of some considerable length than that the water supply should be remote or the cane in distant fields.

"The problem of burning the exhausted chips has not yet been successfully solved, and I doubt very much whether it will be.* Save the softening which the chips undergo in the process of diffusion the difficulty of expressing the water from them is as great as that of expressing the juice from fresh chips. Thus to dry the chips sufficiently to make them economical for fuel would require a vast expenditure of power, which would hardly be supplied by the increased supply of steam generated by their combustion. Experiments during the seasons 1887-'88 at Magnolia Plantation, Louisiana, showed that an ordinary cane-mill was poorly adapted to the pressure of exhausted cane chips. The feeding of the mill was difficult, and the amount of fuel produced seemed wholly disproportionate to the expense of preparing it. It has been proposed to try the process used for extracting the water from beet pulp for the purpose of drying sorghum chips. There is nothing whatever in the experience of the beet-sugar factories to warrant the belief that such a process would render the chips sufficiently dry to burn. Although I would not be considered as discouraging any further attempts in the direction of preparing sorghum chips for fuel, I must be allowed to express the belief that for some time to come coal must be chiefly relied upon.

"If the chips are to be successfully burned in the future we may make up our mind that it will have to be done by previous pressure in mills which in all their appointments shall be as strong and efficient as those which have been in use for expressing the juice from cane. It can not be hoped that these chips will be made sufficiently dry by exposing them to the sun, and in artificial desiccation the amount of fuel required would be almost as great as that used in the evaporation of the original juice. It is claimed that at Wonopringo, in Java, as reported in the New Orleans Item of December 16, 1888, the Fives-Lille Company has succeeded in drying the chips by passing them through two powerful three-roll mills, and that the chips thus dried do not contain more than 55 per cent. of moisture and burn readily in an automatic furnace invented by Godillot. If it be assumed that 100 pounds of chips contain 10 pounds of combustible matter, it is seen that nearly 80 pounds of water will have to be expressed therefrom before they are fit for fuel. I am doubtful whether such a process will prove profitable save in countries where fuel is very dear, as it is in Java and Cuba.

"*Cost of factory.*—It is an almost universal experience that the actual cost of a sugar factory is underestimated by those who undertake its erection. Many of the disasters which have attended the manufacture

* Since this was written further experiments are more favorable to the possibility of economically using the chips for fuel.

of sorghum sugar have been due to miscalculation of the cost of the apparatus necessary for the purpose. It is the part of wisdom to avoid mistakes of this kind, and before undertaking the erection of a factory to fully understand the amount of outlay which will be required. The cost of the factory will, of course, vary according to its capacity and the character of the machinery and building erected. In my opinion there is little economy in using cheap machinery, hastily and poorly put together. Success is more likely to be obtained by using the very best machinery which has been devised for sugar-making purposes, and erecting it in a lasting and substantial manner. The economy which is secured in operating such machinery far exceeds that which would be obtained by erecting a cheaper plant. The character of the building must also be taken into consideration; it should be sufficiently large to allow a proper disposition of all parts of the machinery without crowding, and sufficiently strong to afford a proper support for such portions thereof as may rest upon it. Due regard should also be paid to risks of fire, and that portion of the factory especially exposed to such dangers should be made as nearly as possible fire-proof. The plans and specifications for all the machinery should be carefully prepared under the direction of a competent engineer and architect, and the machinery furnished by manufacturing firms whose experience and reputation are a guaranty of the excellence of their work. For a complete factory, capable of working 200 tons per day, the cost may be estimated at \$60,000 for a minimum and \$100,000 for a maximum, the difference being caused by the elaborateness of the work. This may seem a large sum, but it is highly important that intending investors should know the magnitude of the undertaking which they propose. An estimate which exceeds the actual outlay by \$10,000 will be far more satisfactory to all parties concerned than one which falls short of it by the same amount.

“Technical and chemical control.—The manufacture of sugar from sorghum is no mysterious process known only to one or two persons, as attempts have been made to establish; nevertheless it must be understood that without experience in the manufacture of sugar the most competent engineer may fail. It is best, therefore, that intending investors understand this beforehand that they may be able to secure some one to take charge of the manufacture of sugar who thoroughly understands the needs of the business and has had some experience in the conduct thereof. Perhaps there are not more than fifteen or twenty such men now in the United States, but their number will be largely increased within a short time. It would seem, therefore, that the number of factories which could be successfully operated in the next year or two is limited, and this fact should be taken into careful consideration by those intending to invest money in the business. An intelligent young man of good education, with quick perceptions and of industrious habits, would be able in one year, working in a sorghum-

sugar factory, to obtain a knowledge which would enable him to take charge of a factory, with some degree of success, on his own responsibility. One object which the Department has had in view in its experiments has been in having them open, not only to public inspection, but to careful technical study, to such persons as chose to make the attempt.

"The importance of chemical control of the manufacturing work is so evident that I need not dwell upon it long. The vagaries of the sorghum plant are so pronounced as to require the careful supervision of the chemist at all times. In localities not far removed differences in the character of the sorghum are most marked, as illustrated by the data obtained at Conway Springs and Douglass, Kans., during the past year. To determine the fitness of the cane for the manufacture of sugar, control the workings of the factory, and find and remove the sources of loss in the sugar-house, are duties which can be committed only to the chemist. For many years, at least, this chemical supervision will be necessary, and its utility will always continue."

There are a few observations which the experience of the past season makes pertinent. First of all, until exhaustive studies of the agricultural conditions can be obtained, it may be taken for granted that factories should not be built in arid regions such as were presented last year by Ness City, Mead, etc. It would be criminal rashness to multiply factories in such localities, and a most reprehensible advocacy of the industry to persuade communities or capitalists to invest in them. It may be, as has already been intimated, that some system of agriculture will be devised which will insure with reasonable certainty a good crop. It is not necessary to the success of the industry that a fine crop should be made every year, but it is necessary that a crop of fair quality be assured. It has been demonstrated that under the conditions obtaining this year, such assurance is impossible in the localities mentioned above. The climatic history of that portion of the State indicates that in a majority of the seasons no better results can be expected than were obtained this year. To represent to an already grievously burdened community that favorable results are certain, and on the basis of such a misrepresentation to induce it to further burden itself with an overwhelming debt is a plan of procedure which should deserve only condemnation from official quarters. In respect of the central southern portion of the State two seasons of valuable experience have shown that a crop of high sugar producing quality can be grown. Furthermore, the climatic history of that portion of the State indicates that as a rule such a crop can be made. Doubtless there will be many seasons of poorer crops, but few or any of total failure. Until the sorghum-sugar industry shall have been more firmly established, it is the part of wisdom to confine it to limits whose conditions are already determined. Any transgression of these limits should be the prerogative of culture experiments alone. In view of these facts it would be well if new ventures in sorghum-sugar making, in so far as Kansas is

concerned, should not be found farther west than Medicine Lodge nor farther north than Wichita. In the case of abundant private capital, words of warning are scarcely necessary. The capitalist, even if the venture miscarry, is not bankrupt. Official reports should be calm, dispassionate, and unbiased. Representing in these matters the Department, I desire to appear neither as an enthusiast nor an alarmist, but I deem it my duty to fully apprise every interested person, not only of the possibilities of success but also of the dangers of defeat. It is my purpose to prevent official reports from being used to promote the erection of sugar factories in impossible places. Success will never come to sorghum from coercing nature with Congressional appropriations and town and county bonds. Wise protective legislation, judicious experiment, and patient investigations will gradually lead the way to success if success is to be obtained. My advice to each community, however, in respect of sugar factories, is to await the investment of private capital. There is danger in every project of essentially a private nature which depends for its inception on the pledge of a local bonded indebtedness. There are already enough factories built to test the possibilities of sorghum. Wait and see what the result will be. It may be further stated that this view of the matter has been reached after careful consideration incited by the reception of numerous letters from various localities in Kansas, asking advice in respect of voting bonds to sorghum-sugar manufactories. There is no question of the fact that success will come, if it come at all, to the sorghum-sugar industry, not through the present multiplication of factories, but by making even one factory thoroughly successful. Not a single town or county bond is needed for this result.

In respect of the water supply, the disasters of the past season speak more eloquently than words. It has been demonstrated that a sufficient water supply can not be had from a well. The factory of Medicine Lodge owes its success chiefly to its inexhaustible supply of water. The sooner the other factories are placed on the banks of streams, which even in the driest seasons furnish surface water, the better. It is possible that in the immediate Arkansas Valley a sufficient number of wells might be secured to supply a factory with water, but in this case even it is much safer to lay a pipe to the river. With our present knowledge it should be well understood that any one proposing to erect a new factory and to take the water supply thereof from a well, represents a thoroughly unreliable plan, and is unworthy of credence or support. Before last season the well, as a water supply, was an improbability; now it is an anachronism. There is water enough in central southern Kansas to supply a hundred sugar factories. There ought not to be money enough in the whole country to build one depending on a well. The man who honestly visits a locality in the interests of a sorghum sugar factory will look for water before he asks for bonds. Have nothing whatever to do with him who asks for bonds first. There is another

point which ought to be considered in voting bonds. A good sugar factory, to give promise of success, will cost fully \$100,000. In granting bonded aid assurance should be given that the beneficiaries have also something to invest and that they will invest it. A town granting \$20,000 should be certain that the other \$80,000 are forthcoming. To throw together a collection of crude and cheap machines, unwisely placed and rudely covered, is a method of sorghum-sugar factory building that has already had ample illustration. The community which becomes a participant in a work of this kind should be protected in some way against such disasters. I would be willing to withdraw my objection to bond voting, could I see a town aiding to the extent of \$20,000 in the erection of a factory on an ample stream of water to which are tributary some thousands of acres of excellent cane land in an approved climate, and under the control of men who have carefully studied the whole problem of sugar-making, and who would bring to the work \$80,000 of their own money and the best technical and chemical skill that could be obtained.

Two factories have been operated in such a way as to almost pay running expenses. In a general review of their work it can be seen that, with a more perfect adjustment of parts, the balance of the books would have shown a profit. The most discouraging point in connection with such work is the depressing effect it has upon the industry. Men who have worked hard, night and day, spending not only their time and energy, but also their money, and without return, can not be expected to persevere. There are to-day many men bankrupt or nearly so who a few years ago were in prosperous circumstances. These reverses are due to their attempts to make sorghum sugar. The long list of disasters, now extending over many years, can not fail of their effect, and this effect is not confined alone to those who suffered, but their depression naturally extended to others who, in other circumstances, would be ready to embark in the industry.

Many of those who have suffered have been led to go into the business by having represented to them only one side of the problem, or by statements presumably from those properly informed, calculated to deceive and mislead. In other cases the unfortunates have only themselves to blame. inasmuch as they have had access to all the facts and have not made use of their opportunities.

SUMMARY OF CULTURE EXPERIMENTS.

The most instructive fact connected with the culture experiments is revealed by the statement of the results obtained in localities receiving markedly different quantities of sunlight. These differences were also attended by varying quantities of rain. It is, however, apparent that moisture, when not present in excess, is beneficial to the crop, and the

following principles will be easily established by the experience already obtained:

(1) The quantity of moisture being furnished necessary to the proper growth of the cane, the content of sugar, other things being equal, will depend upon the total quantity of sunlight received.

(2) Excess of moisture diminishes the content of sugar both by reason of interfering with the proper nutrition and cultivation of the plant, and by reason of being conditional on numerous cloudy days, diminishing the quantity of light and heat received.

(3) The content of water in mature normal canes is but little influenced by the rain-fall.

(4) A mean summer temperature of 70° Fah. for the three months of June, July, and August gives a minimum of heat necessary to the maturation of the earlier varieties of cane.

(5) South of the mean isotherm of 70° Fah. for the summer months is a broad belt suitable for the growth of sorghum, the most favorable portion of which is the semi-arid region of the southwestern central portion of the United States.

(6) The corresponding arid regions of the country would become suitable to sorghum production, with a minimum amount of irrigation.

(7) On account of the frequent recurrence of very wet seasons in all regions east of the Mississippi River, the commercial success of sorghum, as a sugar-making crop, in those localities is not to be expected.

(8) The cause of a poor yield of sugar in sorghum of high polarization is due to the presence of some form of carbohydrates or other organic body, exercising a higher melassigenic power than invert sugar or any form of levulose and dextrose.

(9) The tendency of selected seeds from rich canes to produce a uniform crop of high polarizing canes is established under favorable thermic and photic conditions.

(10) The possibility of developing, from existing varieties, a permanently improved crop capable of cultivation for manufacturing purposes is fully assured.

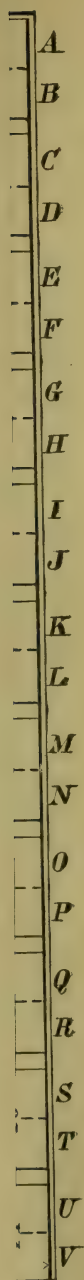
(11) The prospects of doing this with two or three of the standard varieties is more promising than dependence on an experimental or fortuitous development of a new variety free from the faults inherent in sorghum.

Important aid which the Department can extend to the sugar industry of the future is in the line of culture experiments and work with new processes of separating the sugar from the molasses, or in other new and untried lines of work which contain any promise of success. In respect of culture experiments, it is also highly important that any aid given by Congress should be provided for early in the season. An appropriation which is often not made until late in the spring and which does not become available until July 1, is of little

Scale: 1 in. = 96 ft.

Field 700'x 622'

[illegible]



value for agricultural work. For this reason the appropriations made for scientific agricultural experiments should be measured by the calendar and not by the fiscal year. I would especially urge that you bring this matter before the agricultural committees of the two houses of Congress, and secure from them suitable recommendations to make the above suggestions effective. Many of the disasters which attended our earlier experiments in the manufacture of sugar were due to the causes above mentioned, and the removal of that source of disaster will doubtless greatly promote the success of our future.

CULTURE EXPERIMENTS AT COLLEGE STATION, MARYLAND.

In harmony with instructions received from you, I made arrangements with Hon. H. E. Alvord, director of the Maryland Agricultural Experiment Station, and Mr. D. M. Nesbit, of College Station, for the growth of many varieties of sorghum. Major Alvord planted 10 acres under this arrangement, and Mr. Nesbit 5.

The land planted by Major Alvord was plotted and numbered according to the plan given in the accompanying diagram.

The composition of the fertilizers employed on the plots indicated by the letters A, B, C, etc., is found in the following table.

The unlettered plots were fertilized with a mixture of the various substances used. The especial object of the lettered plots was to determine the influence of the different fertilizers, and mixtures thereof, on the yield and sugar content of the canes.

Application of fertilizers.

[Capital letters indicate the plot to which the appended fertilizer was applied.]

A—Corn guano.	L—Sulphate of ammonia.
B—Fine bone.	M—Sulphate of potash.
C—Muriate of potash.	N—Mixture No. 1.
D—Mixture No. 2.	O—Acid phosphate.
E—Kainite.	P—Mixture No. 3.
F—Ammonite or cotton-seed meal.	Q—Mixture No. 4.
G—Ammoniated dissolved bone.	R—Dissolved bone-black.
H—Nitrate of soda.	S—Cotton-seed hull ashes.
I—No fertilizer.	T—Mixture No. 5.
J—No fertilizer.	U—No fertilizer.
K—Thomas-slag.	V—No fertilizer.

Basis of application.

	Pounds per acre.
Nitrate of soda (one part).....	320
Superphosphate, dissolved bone, and Thomas-slag (one part).....	480
Muriated potash and cotton-seed hull ashes (one part).....	320
Kainite (one part).....	480
Sulphate of potash (one part).....	320
Sulphate of ammonia (one part).....	320
Cotton-seed meal and ammonite (one part).....	320

Mixtures.

(1) Nitrate of soda, one-half part; superphosphate, one part; muriate of potash, one part.

(2) Ammonite or cotton-seed meal, one part; fine bone, one part; kainite, one part.

(3) Nitrate of soda, one-half part; Thomas-slag, one part; kainite, one-half part; muriate of potash, one-half part.

(4) Nitrate of soda, one-half part; sulphate of potash, one-half part; fine bone, one part.

(5) Sulphate of ammonia, one part; sulphate of potash, one part.

Description of samples of fertilizers used at the Maryland stations.

Serial No.	Fertilizers.	Serial No.	Fertilizers.
6377	Fine bone.	6421	Ammonium sulphate.
6378	Corn guano.	6422	Dried blood.
6379	Muriate of potash.	6423	Thomas-slag.
6380	Kainite.	6424	Nitrate of soda.
6381	Ammonite.	6425	Dissolved bone-black.
6382	Acid phosphate.	6426	Sulphate of potash.
6383	Ammoniated dissolved bone.	6427	Cotton-seed hull ash.

Analyses.

Serial No.	Moisture.	Total phosphoric acid.	Soluble phosphoric acid.	Reverted phosphoric acid.	K ₂ O	Ammonia.
6377.....	7.44	29.68	.....	.....	.....	4.59
6378.....	15.78	14.53	.....	.....	.....	2.24
6379.....	.62	.....	.....	.....	49.97	.....
6380.....	9.58	.....	.....	.....	12.37	.....
6381.....	8.26	4.62	.....	.....	.....	15.12
6382.....	11.78	20.30	11.44	7.00	.....	.44
6383.....	10.67	18.69	6.73	8.09	.....	.....
6421.....	.....	.....	.....	.....	.....	24.45
6422.....	.....	.....	.....	.....	.....	14.90
6423.....	.22	19.59	.....	.....	.....	.....
6424.....	.....	.....	.....	.....	.....	18.05
6425.....	18.31	16.42	15.34	.74	.....	.82
6426.....	12.72	.....	.....	.....	27.50	.....
6427.....	5.96	8.67	.....	.....	25.45	.....

The character of the field-work performed is fully set forth in the following report:

JANUARY 31, 1890.

DEAR SIR: I have the honor to submit the following report upon the essential facts connected with the cultivation, on the farm of this station, during the year 1889, of 10 acres of sorghum, in accordance with a contract made with the U. S. Department of Agriculture, with the terms of which you are familiar, and under your instructions and supervision.

The land, laid off in accordance with a plot furnished by you, had been irregularly and poorly cultivated prior to 1888, and was in low condition. In 1888 it brought a light crop of oats and was seeded to clover. The clover was badly winter-killed (1888-'89), and very little was left growing on the 10-acre square when assigned to the sorghum last April, except a strip a few rods wide across the north side of the field; there a very good clover lay was turned under.

The land was plowed at intervals in April and May, as the season and the condition of the soil permitted; but there were 14 rainy days in April, 20 in May, and 15 in June—24½ inches of rain-fall on this field in these three months—so that work was continually interrupted. Most of the time a team could not cross the field, and progress was very slow.

The planting, which it was intended to do the first half of May, could not be begun till the 18th of June, and was not finished till the 24th. The land was well prepared for a seed-bed before the planting, and the fertilizers applied as described later. After planting, heavy rains came, greatly impeding vegetation and necessitating con-

tinuous hand labor, breaking the surface crust and nursing the young plants as they appeared, in order to secure any sort of a "stand."

The Early Orange, Early Amber, Link's Hybrid, and Kansas Orange were first planted on the four half-acre plots, 1, 2, 3, and 25, in the middle of the field, and "the pedigree seed" in the north section, of about 4 acres, next. These seeds or varieties were nearly all up and in sight by the time the last planting was finished, or on 25th of June.

As already stated, the germination was generally good, but vegetation and early growth exceedingly slow, under the most unfavorable conditions.

The commercial fertilizers used were sent here partly from Washington, by your order, and partly from Baltimore, upon my order, given by your direction and subsequently approved by you.

Samples of all the fertilizers were taken and sent to you, and I have a transcript, kindly furnished by you, of their analyses.

My instructions were to apply fertilizers alike, and at my discretion, to the whole north section of the field, or the four acres assigned to the pedigreed seed. I regarded a complete fertilizer or general mixture as best suited to this purpose and accordingly made three mixtures, of nitrogenous, phosphatic, and potassic materials, respectively, and as follows:

For 4 acres mixed three lots manures, viz :

Lot A : *	Pounds.
Ammonite	300
Dried blood	300
Sulphate ammonia	300
Total	900

Lot B :	
Fine bone	368
Dissolved bone-black	456
Thomas slag meal	100
Ammoniated dissolved bone	456
Acid phosphate	510
Total	1,890

Lot C :	
Muriate potash	360
Sulphate potash	360
Kainite	240
Cotton-seed hull ashes	400
Total	1,360
Aggregate	4,150

These three lots, separately well mixed, were separately applied by being evenly and lightly drilled into the surface soil, with a grain-drill, before the planting. The application was made both ways on the field and very uniformly.

Subsequently, on these 4 acres, after plants had well started, three applications of nitrate of soda were made at intervals of about three weeks, and at the rate of 50 pounds per acre, each time, or 600 pounds of nitrate of soda in all. This made a total of 1,500 pounds of nitrogenous manures, on the 4 acres during the season besides what was contained in the lot B.

The central and southern sections of the field, being together just about 6 acres, were divided, as per diagram on file ("A"), across the field, east and west, into four large half-acre plots, (1, 2, 3 and 25), and five rows of eleven small plots each. This

* See subsequent note as to nitrate of soda.

grand division was then laid off into twenty-two strips or plots for different fertilizers, these running from south to north, *i. e.*, from southern boundary of field to northern boundary of plot 1 (Early Orange). And these twenty-two special-fertilizer subdivisions were designated by letters A to V inclusive, beginning at east end, or south-east corner of field.

Each of these plots or subdivisions crossing or including several plots, was called three-tenths of an acre, but more accurately contained .275 of an acre. Fertilizers were applied to these with grain-drill run south to north before planting, in accordance with a schedule received from your office May 3, 1889. Including three of these subdivisions (J., U., and V.), on which no fertilizers were used, the twenty-two subdivisions or 6 acres received in all, 3,096 pounds of commercial manures, or about 500 pounds per acre. All this was applied, mixed into the soil, just before planting. No other application was made.

I regret to find that in one particular I failed to follow what was a suggestion of yours rather than an order. In a postscript to one of your letters last May, you proposed that the nitrates should be applied early, and the phosphates later. This piece of letter was misplaced and lost sight of till I gathered together all papers for preparing this report. But as the season turned out, I think no harm resulted from this omission. With our continual rains, often very heavy, there would have been great loss had the nitrogenous manures been all applied at once and in advance. While as the plants really did not begin to *feed* till July, it was manifestly inexpedient to delay phosphatic manuring to a later period.

The most interesting and instructive of the field-notes relate to the subdivisions of the long half-acre plots, 1, 2, 3, and 25. These were of same variety of cane, same planting, and subject to the same conditions throughout, on each of these four ploas, except the difference in the fertilizers applied across them, on the twenty-two subdivisions marked A to V inclusive. Although the crop on these plots was, as a whole, late, light, slow, and poor, for the whole season, whenever, on either plot, a subdivision was reached having certain fertilizers, there the crop was good. For examples: (1) B, with fine ground bone, was fair to poor; C, with muriate of potash, E, with kainite, and F, with ammonite, were poor all through; C was very poor. But D, between C and E, receiving mixture No. 2 of ammonite, fine bone, and kainite, was very good all through the season. (2) Similarly, plot L, sulphate ammonia, was very poor; M, sulphate potash, was poor, and O, acid phosphate, was fair to poor. But N, between M and O, receiving mixture No. 1, of nitrate soda, superphosphate, and muriate potash, was good all through. Q, with Mixture No. 4, was good to fair. These remarks apply only to appearance of growing crop.

When the time came for sampling and sending samples to you at the Department, your instructions were carefully observed, and as every sample was marked, and you have the record complete of what you thus received, nothing further on this part of the subject is here introduced. Shipments began September 23, and ceased October 22.

For the sake of carrying as far towards maturity as possible, nearly all the cane not cut in sampling was allowed to stand till after several severe frosts. There was not enough of any one kind or plot to get acreage results and save a sufficient quantity for sampling, unless a *very* small fraction of an acre was used, from which to compute crop product. Such a record was therefore attempted in only a few cases; those gave these results:

Plot No.	Variety.	Rate of cane per acre.
		<i>Lbs.</i>
97	New Orange	25,800
100	Cross of India	19,800
112	Cross of White India	20,400
117	Cross of Amber and Orange	21,600

The following miscellaneous notes are found: First planting, June 18; first plants above ground, June 21.

First varieties to show heads or tassels, viz: August 24, 1889—

No. 34 (*bis.*), Whiting's Early; No. 34 (*ter.*), Whiting's Early; No. 96, Cross of Orange; No. 245, Black-seed Bi-color; No. 246, Red-seed Bi-color.

From a mass of other notes on hand I can find nothing which I think will be of service to you.

But you may discover omissions, and if you do, please call further for what you want and I will furnish it, if possible.

Let me remark before closing that I hardly think it will be expedient to grow so large an area in sorghum and such a variety another season under any circumstances, but I have carefully preserved the boundaries of the plots and should be especially pleased to co-operate with you in growing sorghum again on 5 or 6 acres of the specially-fertilized plots. The sugar question aside, I believe much of interest and value could be derived from continuous cane-growing on these plots with special feeding. We shall be prepared to join you in such work on most favorable terms, and if the season of 1890 *approaches* the normal, we are sure this piece of land will be found specially adapted to sorghum growing.

Very respectfully, yours,

HENRY E. ALVORD.

Director Maryland Agricultural Experiment Station.

Dr. H. W. WILEY,

Chemist, U. S. Department of Agriculture, Washington.

RESULTS ON MR. NESBIT'S FIELD.

INFLUENCE OF FERTILIZERS ON SUGAR CONTENT AND TONNAGE.

The disastrous floods and continuous rains of the season almost destroyed the lettered plots in the Nesbit field; the link's Hybrid variety and many plots of the Kansas and Early Orange being destroyed. The Early Amber was the only variety that furnished a stand on every plot.

The number of days on which rain fell (Washington Station distant 8 miles), and the total precipitation from May 1 to October 1, as taken from the records of the Signal Office, are as follows: Number of days on which rain fell, 71; total precipitation, 30.88 inches.

Number of days on which .01 inch or more of rain fell and amount of rain-fall, in inches, from May 1 to October 1, inclusive, 1889, at Washington City.

Date.	Washington City.	
	No. days on which .01 or more rain fell.	Total rain-fall.
1889.		<i>Inches.</i>
May	16	10.69
June	14	5.01
July	15	8.13
August	10	3.07
September	15	3.88
October 1	1	0.10
Total	71	30.88

The results of the field work, with notes thereon, are given in the following letter from Mr. Nesbit:

COLLEGE STATION, MD., November 1, 1889.

DEAR SIR: According to contract, I prepared the ground—five acres—selected by you by plowing, subsoiling, harrowing, and rolling. An extraordinary amount of work was bestowed on the land, with the result of a very fine condition of tilth. It was my intention to plant about the 1st of May, but heavy rains following in close succession prevented. The planting was not finished until the 20th of June.

The fertilizers were carefully mixed and applied according to the schedule furnished by you, but a heavy rain and a flood following the application interfered with the fertilizer tests so far as to make them unreliable.

The quantities of seeds furnished of some varieties was insufficient, and some did not germinate freely so that the stand was not perfect in all the plats.

The growing cane was cultivated as thoroughly as the rains would permit, and within sixty days from planting the more forward varieties showed many seed heads.

A storm with strong north wind prevailed September 11, 12, and 13, which beat and broke much of the cane in some plats, while other plants suffered very little.

Samples of cane were shipped to you almost daily during six weeks following September 10. The shipments included at least two samples from each plat, excepting No. 207, and as all were duly marked, I assume that you have a sufficient record of them.

The cane was killed by frost on October 8.

Very respectfully,

D. M. NESBIT.

Dr. H. W. WILEY,

Chemist, Department of Agriculture.

EFFECT OF DIFFERENT FERTILIZERS ON SUGAR CONTENT.

The season was not only a poor one for the maturation of the cane but also for observing the effect of different fertilizers on the sugar content of the canes. In the case of the Early Amber variety it is clearly seen that only the last analyses in October indicate a cane approaching maturity. For purposes of comparative study the earlier analyses are valuable rather for determining the acceleration or retardation of the growth than for actual content of sugar shown.

The three highest percentages of sucrose were obtained in plots M, P, and V. Plot M was fertilized with sulphate of potash, P with mixture No. 3 (nitrate of soda, phosphate slag, kainite, and muriate of potash), and V received no fertilizer whatever.

The three lowest percentages of sugar were obtained in plots E (395), C (550), and M (555). These plots were fertilized with kainite (E), muriate of potash (C), and sulphate of potash (M). The earlier analyses, however, as before stated, are entirely unreliable for purposes of discriminating between the effects of fertilizers.

It is interesting to note that the increase in sucrose, as indicated by the last set of analyses, has been attended with very little decrease in the percentage of reducing sugars, whereas with more favorable season,

as is seen in the results of the Kansas work, the decrease in the percentage of reducing sugars is quite marked and often at the stage of full maturity.

Even had the season been favorable it would not be wise to state any positive results from a single year's trial. It is to be hoped that opportunity will be given to continue similar experiments for a number of years in succession in order that definite conclusions can be reached covering seasons of different climatic conditions.

The seed planted was obtained from the Department Experiment Station at Sterling, Kans., and the best average samples of cane from the plots yielding the seed showed a content of 13.70 per cent. sucrose. (Bulletin No. 20, p. 126.)

In the case of the Early Orange plots the analyses show no appreciable progress in development after the first set of analyses. In fact, in many cases the last analyses show a lower sucrose content than the first. The results show in a most striking manner the disastrous effects of a thoroughly wet season and indicate that successful sugar-making from sorghum must be confined to an area where such seasons are of rare occurrence or never occur at all. The best samples of canes from the plots at Sterling in 1888, from which the seed was taken for Early Orange plots, show the following contents of sucrose:¹

	Sucrose.
Early Orange seed from—	<i>Per cent.</i>
Kansas	12.82
South Carolina	13.62
Arkansas	11.39
Louisiana	12.90

CEDAR FALLS.

ABSTRACT OF THE REPORT OF JOHN BOZARTH.

The crop of Early Amber was grown from seed produced on the farm. The seed which has from time to time been obtained from Kansas has not proved satisfactory. The planting began April 29 and continued one month; 100 acres were planted by Bozarth Bros. and 200 acres by neighboring farmers. As the manufacturing season approached it became evident that the conditions for sugar production were not favorable. The very dry weather greatly injured the crop, no rain having fallen from July 1 till August 8. Several attempts were made to produce sugar, but with negative results. It was found impossible to grain the sirup in the pan, and on standing a long time in the hot room only a light crop of crystals was obtained. In all 140 pounds of crude sugar were made; in addition to this 130 pounds of sugar were made from sirup obtained from Mr. Newton, 20 miles distant.

¹ Bull. No. 20, p. 125.

ABSTRACT OF THE REPORT OF A. E. KNORR.

On my arrival at Cedar Falls, early in September, it was seen that there was no prospect of producing sugar. Owing to the drought everything was parched up. Only three attempts were made at boiling the sirup for sugar. The first run for sugar was made on September 10, from ordinary field cane. The analyses of the juice of this cane were as follows:

	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Total solids.....	14.37	16.27
Sucrose.....	6.68	7.60
Glucose.....	6.30	5.93
Purity.....	47.71	47.80

As might have been expected from the low purity, no granulation was obtained. On September 17 another strike was made on a lot of cane which had been selected from a locality where picked samples of a very high purity had been found. The analyses of three samples of mill juice from this cane are as follows:

	No. 1.	No. 2.	No. 3.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Total solids.....	16.29	15.73	14.66
Sucrose.....	9.13	7.11	8.35
Glucose.....	5.75	6.49	5.10
Purity.....	56.36	45.29	56.42

To attempt to make sugar from the above material, of course, resulted in failure, although a small crop of crystals was obtained.

The first heavy frost occurred on September 19, and the works were closed September 29.

On October 3, Mr. Knorr, according to instructions, visited Ames, Iowa, to be present at the experiments made with the Jennings process. The cane used had been partly frost-bitten and cut for over a week. The sirup obtained was very dark in color and no attempt was made to produce sugar from it. In spite of the bad results the management of the Iowa station is still confident of securing good results with the Jennings method. The advantage claimed for Mr. Jennings's process is that it is a battery consisting of a single cell, small capital is required to build it, and it can be worked very economically.

RIO GRANDE.

ABSTRACT OF THE REPORT OF H. E. L. HORTON.

Mr. Horton's report was of a very elaborate nature containing, first, a compilation of data obtained during nine year's work at Rio Grande; second, an agricultural study of the season of 1889; third, a record of the run made with the battery on October 12, 1889, and fourth, a brief description of the machinery employed during the season.

The analyses for the season of 1889 commenced on the 21st of September, with samples of Amber cane, which variety continued to be tested until the 23d. The maximum percentage of sucrose in the juice found during this time was 10.05 and the minimum 7.80. From September 23 to October 9, tests were made of the Kansas Orange planted on May 18. This proved to be of very poor quality, the maximum percentage of sucrose being 8.45 and the minimum 3.99. Kansas Orange was again tested from October 10 to 21 with better results than at first, the maximum percentage of sucrose found being 9.14 and the minimum 6.76. The character of the cane improved after the 21st of October, several analyses being made on that day, and the maximum percentage of sucrose found in the juice being 13.23.

Analyses of late orange planted on the 16th of May, were commenced on November 7, and continued until the 13th, showing cane of average poor quality, the maximum percentage of sucrose in the juice being 10.03 and the minimum 4.29. The analyses were continued until the 16th of November, but without showing any improvement in the character of the cane.

Analyses of twenty-cell drawings.

[Run October 12, 1889.]

Cell No.	Temperature, C°.	Brix (corrected).	Sucrose.	Cane in Cell.
		°	<i>Per cent.</i>	<i>Pounds.</i>
1	21.5	11.72	6.42	307
2	20.0	10.35	5.60	307
3	20.0	11.35	6.13	307
4	23.0	10.05	5.41	307
5	24.0	11.81	6.22	307
6	24.0	10.79	5.64	307
7	22.0	11.99	6.41	307
8	22.0	11.19	5.93	307
9	24.5	13.11	7.22	307
10	24.5	12.81	6.98	307
1	23.0	13.35	7.51	307
2	23.0	12.95	7.13	307
3	24.0	13.61	7.65	307
4	23.5	12.95	7.23	307
5	23.5	13.85	7.85	307
6				307
7	20.0		7.75	307
8	22.0		7.60	307
9	20.0	13.85	7.65	307
10	22.0	13.79	7.65	307

Analyses of ten eleventh-cell drawings.

Cell No.	Temperature, C°.	Brix (corrected).	Sucrose.
		°	<i>Per cent.</i>
1	24.0	12.7	6.88
2	23.5	12.9	7.18
3	24.0	12.9	7.33
4	24.0	13.5	7.61
5	19.0	14.1	7.44
6	20.0	14.3	8.12
7	20.0	14.3	8.32
8	20.0	14.3	87.9
9	20.0	14.2	8.03
10	20.0	14.3	8.07

Analyses of ten eleventh-cell drawings—Continued.

	Temper- ature, C°.	Brix (cor- rected).	Sucrose.
		°	<i>Per cent.</i>
Milled chips	30	14.2	8.86
Diffusion juice		14.2	8.10
Exhausted chips			1.25
Milled cane	21	14.74	9.14
Mean of milled cane and milled chips		14.47	9.00

The first point to call attention to on examining this run is the question: What is to be taken as representing the sucrose number during an experimental run? The chips from shredder and the samples of whole cane do not give agreeing sucrose numbers.

The following observations were made during a run of several hours October 2, 1889:

(A) Seventy-six pounds of carefully hand-stripped cane were milled; when one-half had been run through, a sample of the juice was analyzed, then the remaining half was run through and the two portions of juice mixed and analyzed.

	Brix.	Sucrose.
	°	<i>Per cent.</i>
First hslf.....	13.3	6.38
First half+second half....	13.3	7.31

(B) This sample consisted of two handfuls taken from every basket as packed, twenty in all, well milled and juice analyzed.

	<i>Per cent.</i>
Brix.....	12.8
Sucrose.....	5.97

(C) This sample of about 200 pounds represented $1\frac{1}{2}$ tons of cane. A handful was taken from every lagging of the carrier running from the shredder while $1\frac{1}{2}$ tons were worked.

	<i>Per cent.</i>
Brix	13.0
Sucrose	6.63

The sampling and analyses show how difficult it is to obtain a sucrose number which may be said to represent the cane worked during a run.

In the run of October 12, the results of the milled chips and milled cane are given.

Let us look at the dilution from standpoint of total solids as given by Brix instrument. The milled chips have an average Brix of 14.47, the diffusion juice a Brix of 14.2. How has this been reached?

Two factors suggest themselves in the solution of the question: (A) Evaporization from surface of cells sufficient to make one degree difference in spindle reading; (B) the high temperature dissolving out the inorganic portions of the cane abnormally. Experiments conducted at

Rio Grande, point strongly to the fact that a dilution of 20 per cent., 30 per cent., or even 40 per cent., as in some cases, is not necessary to a good extraction. This question of dilution is one of greatest importance, for here the cost of producing an hundred weight of sugar will be materially lessened by cutting down the water used.

I have collected the following interesting data showing juices obtained at different factories.

Place.	Raw juice.		Diffusion juice.		Remarks.
	Brix.	Sucrose.	Brix.	Sucrose.	
	°	<i>Per cent.</i>	°	<i>Per cent.</i>	
Mironowka ¹ (Russia).....	16.41	12.72	9.33	7.32	Ordinary.
Wonopringo ² (Java).....	18.60	16.83	14.70	13.31	
Magnolia ³ (U. S. A.).....	16.40	14.10	12.90	11.00	
Mironowka ¹ (Russia).....	15.61	12.00	11.06	8.72	After Turkiewicz.
Landen ⁴ (Belgium).....	15.70	12.94	11.19	9.27	
Rio Grande, ⁵ 1888.....	12.36	6.54	11.83	6.02	
Rio Grande, 1889.....	14.47	9.00	14.20	8.10	

¹Deutsche Zucker-Industrie, 12, 29, 950.

²Sucrerie Belge, October 15, 1888, No. 4.

³U.S. Department Agricultural Bulletin 21, p. 30.

⁴Zeit. Rübenzucker-Industrie, 1889, 375.

⁵New Jersey Agricultural Experiment Station Bulletin 51, page 22, 1888.

In connection with this season's work it will be interesting to see what Rio Grande experiments have already given, and for this purpose Dr. Neale's¹ work may be made use of. His analytical results are as follows:

	Brix.	Sucrose.
	°	<i>Per cent.</i>
Fresh cane, shredded.....	12.36	6.54
Diffusion juice discharged from "eleventh" cell.....	11.83	6.02
Juice from exhausted chips.....		0.82

Dr. Neale's extraction in one case was 89.8 per cent.; in this case 85 per cent. In the experimental run of this year (October 12, 1889) 86 per cent. expressed the extraction. In studying these numbers the small sucrose per cent. must bear a prominent part. Had our sucrose been 12 or 13 per cent. our extraction would have been between 90 and 95. This must not be forgotten.²

MACHINERY.

Battery.—The battery this season is a new one and has many improvements over the one used in 1887 and 1888. In a run from September 12 to November 12 it never ceased to give satisfaction.

¹New Jersey Agricultural Experiment Station Bulletin 51, page 22, 1888.

²The comparison of a specially controlled experiment with a few cells with the mean working of a battery for a whole season is likely to lead to mistaken ideas of efficiency. The only proper comparison would be between the results obtained for a whole season. This note is added to prevent any misapprehension of the terms "Rio Grande, 1888," and "Rio Grande, 1889."—H. W. W.

The battery is to-day and has been in past only on an experimental, laboratory scale, and the work accomplished with it as such has been of the very highest grade; the run of October 12 shows what it did in ordinary working and under good supervision can repeat this record eighty days out of ninety.

This battery was never designed to supersede the German type. Its inventor and others who have studied it carefully can not claim this for it. It was an attempt to manufacture sugar with simplified machinery and at a figure slightly higher than the recognized minimum working with a large plant. It seems to me that this battery can never compete with the German type when it is desirable to work 200 tons per day, for its capacity seems to be that of a 70-ton house, and its usefulness in a small house can not be questioned; but as a factor in solving the economic production of an indigenous sugar for the United States it has little value.

Studies were instituted on the effect of temperature, dilution, and time of contact of water with fresh chips, and in all cases interesting results were obtained. The work shows, as Turkiewicz has already shown with beets, that the time of contact is the weighty factor in extraction, and not heat and quantity of water used.

The Rio Grande battery is all that could be wished for to carry out the line of investigation begun this summer. The heat was controlled nicely, the quantity of water to within a pound, and the contact by dipping baskets one or more times.

The experiments were preliminary and necessarily not conclusive, but it is to be hoped they may be carried out in the near future.

Cleaning apparatus.—The shredder was the interesting machine in the house, for, to a certain extent, the extraction depends on the size of the chip.

With small chips only 0.5 to 0.8 per cent. sucrose remained in chips, with medium chips 0.9 to 1.25 per cent., and with coarser chips as high as 2.4 per cent. To obtain a chip to allow of 0.5 to 0.8 per cent. remaining in bagasse is no easy matter, for the shredder chokes every ten minutes; but this end may be secured by running chips through a second shredder, in fact, this has been suggested¹ by several, but not until this year has the demand seemed imperative, and now double shredding is called for.

¹ H. A. Hughes, Bull. 20, 36, 1888.

MORRISVILLE.

ABSTRACT OF THE REPORT OF W. MAXWELL.

The report begins with a statement concerning the extent of the estate of the Virginia Diffusion Sugar Company, the character of the soil, the cultivation of the crop, notes on the progress of the growth of the crop, and a description of the factory.

The character of the crop produced is given in a series of tables showing the number of acres in each plot, the variety of cane planted, the date of planting, date of sampling, and the composition of the juices. In general the character of the juice shows the cane grown on the plantation of the company was poor. Only one sample of the cane produced on the company's plantation showed 10 per cent. of sugar in the juice; this sample was Link's Hybrid, planted May 27, and analyzed on October 16.

The mean results obtained from the different varieties are given in the following table:

Averages of varieties.

No.	Variety.	Acres.	Brix.°	Sucrose.	Glucose.	Purity.
				<i>Per cent.</i>	<i>Per cent.</i>	
1	Early Amber	53.0	12.4	5.5	2.4	43.3
2	White African	6.0	15.6	9.3	2.8	59.5
3	Early Orange	42.5	14.9	7.4	2.2	49.0
4	Late Orange	17.0	15.4	8.4	2.2	54.4
5	Improved Orange	28.0	16.4	7.9	3.6	49.3
6	Link's Hybrid	4.5	16.4	10.1	4.6	62.0
		151.0	15.1	8.1	3.0	52.9

Samples of cane grown by neighboring farmers showed uniformly better results than were obtained on the estate of the company. The mean results obtained from the various sources above mentioned are given in the following table:

No.	Name.	Variety.	Soil.	Brix.°	Sucrose.	Purity.
					<i>Per cent</i>	
1	W. Anderson	Early Amber..	Sandy loam.....	13.4	6.7	49
2	Mrs. Edwards (a)	do	Black loam	16.4	10.6	64
3	Mrs. Edwards (b)	Early Orange ..	do	15.2	8.2	54
4	Mrs. Zimmons	Early Amber ..	Light gravel.....	16.3	10.4	64
5	Mr. Brown	do	Sandy loam	17.1	10.8	63
6	Mr. Crop	do	Red gravel	18.2	12.0	66
7	W. Jones	do	Light sand	15.7	11.5	73
8	R. Munroe (a)	do	do	18.0	11.6	64
9	R. Munroe (b)	do	Dark loam	16.4	9.9	60
10	Mr. Crittenden	do	Red gravel	14.4	8.2	58
			Averages ..	16.1	9.9	61.5

NOTE.—All these plots were seeded during the first week in May and the canes were samples from September 26 to October 7.

The working of the battery and apparatus in general was of the poorest quality, the inference being drawn that a well-appointed mill would have expressed the same quantity of juice as was obtained by

the diffusion battery. From the agricultural and from the milling stand-point the sugar season of the Virginia Diffusion Sugar Company's plantation was not a success. If a remunerative crop had been produced the mill was not in order to work it, and if the mill had been ready there was no crop to be worked.

KENNER.

ABSTRACT OF THE REPORT OF DR. W. C. STUBBS.

Four plots of over 2 acres each were devoted to the culture of those varieties of sorghum which past experience had demonstrated to be the best for sugar-making. Experiments were also carried on at the State experiment station at Baton Rouge and at Calhoun and on the estate of Mr. F. L. Maxwell in Madison Parish. The results of the attempts to make sugar in the sugar-house were rather disappointing; although considerable quantities of sugar were made it was found almost impossible to dry it in the centrifugals, and the sugar obtained was generally of a low grade. Full data of the sugar-house work are given; also of the analyses of the samples grown at the various experiment stations.

The result of the work is summed up in the following review of results:

REVIEW OF RESULTS.

The sorghum grown at Kenner was of an inferior character; that grown at each of the other stations and at Mr. Maxwell's very fine.

The soils of each of these places vary greatly. At Kenner the soil is a black, heavy, tenacious clay, hard to cultivate and harder still to drain, susceptible of injury from extreme drought or excessive rain-fall. Small seed if not too deeply planted germinate quickly in it. At Baton Rouge the brown loam of the bluff formation prevails; a soil which withstands drought well, but can not endure excessive rain-fall. Small seed are with difficulty germinated, due to the soil puddling and forming an impervious crust after every shower. It works with ease, but it is difficult to drain. At Calhoun there exist the sandy and loamy tertiary soils, easily worked and drained; a soil whose physical properties are good and which needs only proper fertilization to make excellent crops in propitious seasons.

At Mr. Maxwell's we have the typical alluvial soil of the upper Mississippi bottoms; a sandy soil easily worked and drained and of great fertility. These four soils well represent all the soils of the State, save the red lands of Red River bottoms and the light prairie fields of southwestern Louisiana.

The season at each of these places varied greatly during the period of the growth of sorghum. At Kenner a prolonged drought following a heavy rain-fall of April 13 greatly injured the sorghum, making it small and spindling. When the rains began on last of June it produced

suckers, greatly to the detriment of the cane. The cane-borer also attacked the sorghum at Kenner and did it considerable damage.

The same drought prevailed at Baton Rouge, but the seed planted in April did not germinate till June, and hence the young plants were not stunted as at Kenner. No worms or suckers interfered.

At Calhoun most propitious seasons prevailed and the canes were fair in quantity and quality.

At Mr. Maxwell's fine seasons prevailed in the early growth of the cane, but near maturity a prolonged drought was encountered which doubtless injured the cane.

In reviewing the agricultural results, it may safely be asserted that dry well-drained loamy soils are best adapted for sorghum, and that showers at regular intervals favor a large sugar content as well as tonnage. Neither droughts nor excessive rain-falls are favorable to a full development of this plant.

Another feature worthy of note: Only certain varieties of sorghum have given good results anywhere. Link's hybrid, originated by Mr. Ephraim Link, of Greenville, Tenn., seems to have succeeded best on a large scale than any other variety. Of the 100 varieties tested this year for the first time only a very few are worthy of further trial.

The sugar-house results were disappointing. In every instance difficulty was experienced in graining in the pan. Only by the addition of crystallized sugar, or by the withdrawal for some time of heat, could graining be started. Even at a temperature of 120° Fahr., with a vacuum of 26 to 28 inches, no grain could be formed. Does our sorghum contain more dextrine and soluble starches than that raised in Kansas, or did we diffuse at too high a temperature? Our records show temperatures ranging from 40° to 80° C. in our discharging-tanks, and yet no perceptible difference in the sirups. Samples of all the molasses have been kept to further study their compositions.

Our greatest difficulty was in purging our massecuite, a great surprise to all. After running the centrifugal sometime it was found on examination that a layer of sugar adhered to the sieve, upon which rested a layer of molasses, and this in turn was covered by a layer of white foam, giving the appearance while the centrifugal was in motion of a beautiful white sugar. After stopping the centrifugal these layers had to be broken down and mixed with a little water and centrifugalled. In this way a good sugar was obtained, but only at the expense of time, patience, and considerable loss of sugar.

CONWAY SPRINGS.

ABSTRACT OF REPORT OF E. A. V. SCHWEINITZ.

The machinery was not tested until August 25, although this might have been done several weeks before; but, for some inexplicable reason, the work was allowed to drag, with, of course, detriment to the business. A difficulty was met with at the beginning which it took several days'

time to remedy. The drag which furnished the cane to the large cutter was not properly placed, and the knives of the cutter were too broad, causing the cane to be forced back at each stroke. It was necessary, therefore, to attach a forced feed to the cutter. This delay was unfortunate, and caused considerable dissatisfaction.

Last year the mill depended for its water supply upon a deep well which was by no means sufficient. In addition, the well pumps gave a great deal of trouble and caused considerable loss of time. Through some unpardonable oversight this defective piece of machinery had never been touched since last season, and work had scarcely been started before the troubles of last year were repeated. With the enlarged capacity of the house the pipe line to the creek did not give sufficient water, and it was necessary to rely upon the well for water for condensing purposes. Instead of remedying this defect at once several weeks' time were wasted, the work in the mean time lagging, as it was necessary to run first one part of the house and then wait till the other had caught up. Finally, a pond was made near the mill, and the waste water collected and used over again for condensing purposes.

It was the intention of the company to clarify the juice by adding lime, and allowing the limed juice to be brought to a boil in a continuous flow skimming-pan. The pan provided for this purpose was deficient in capacity, and only a very poor defection was obtained. The company was very fortunate, therefore, in securing from the Douglas Sugar Works the loan of five clarifiers, as well as several pumps, and forty sugar wagons. Delay resulted in placing these, but without them little work could have been accomplished. Contrary again to better advice, I understand the engine relied upon for working the centrifugals was insufficient, and the house had to be shut down until a new engine could be purchased and placed.

All of these delays were caused by defects patent from the beginning, and which past experience should have induced the company to provide against. The greater portion of the month of September was consumed in this way, and only about 1,500 tons of cane cut, which should be only a week's work. Very valuable time was thus lost, at great expense.

These troubles seemed to have induced a sort of demoralization generally, and while, during the month of October, work was somewhat more steady, there were many delays caused by broken drags, elevators and pumps; many accidents, the result of gross carelessness, others, perhaps unavoidable.

The double effect caused some delays by the tubes becoming coated with scales, necessitating the removal of the heads of the pans and the scraping of the tubes. In the hands of an intelligent workman the loosening of this scale, with a strong solution of caustic soda, and its subsequent removal by washing the tubes with dilute acid, should have been sufficient.

The exhausted chips were removed from the batteries by means of carts and dumped on the adjacent prairie. This is certainly a very sure way of disposing of a troublesome by-product, but a rather expensive one. Four two-horse carts, with drivers, and six additional men, were employed for this work per twenty-four hours, at an expense of about \$19. The work should have been done with three or four men less, but even then the method is too expensive. The chips furnished by the shredders the early part of the season were very fine, and in excellent condition for diffusion. Later, the knives became badly gapped from bolts and pieces of iron which found their way to the shredders, and little attention was paid to grinding and setting the knives properly. Hence, with a very large dilution, only a moderate extraction was secured. The new battery gave better results than the old. This was due partly to the shape of the cells of the new battery, narrowing toward the top, with small top door, but chiefly to the larger juice pipes, a better circulation being thereby secured. A number of the yokes to the top doors of the cells were broken, causing some delay. This was due to a fault in the casting. The only advantage gained by having the two batteries was that work could be continued with the one when the other was stopped. It would be far better to have a battery with an extra pipe line, which would permit of any cell being cut out of the circuit when necessary. A saving of labor, fuel, and water is thereby secured, as well as a proportionately smaller dilution, and just as much work could be accomplished.

To sum up in general, we may say that the heavy machinery was entirely adequate and suitable for the work, and that the delays and troubles should not be charged to this, but rather to carelessness and inexperience.

In the early part of the season but little inversion of sucrose was noted in the battery. Later, this increased, and it was deemed advisable to add sufficient lime to the chips in the battery to correct this. Skimmings and settlings were returned to the battery. The juice was limed to neutrality, or as nearly so as possible, and a good clarification secured; still, some inversion was noted between the clarified juices and semi-sirups. This was due chiefly to the manner in which the juice was handled, as for a long time the management pursued a method of allowing the juice to stand and "settle" before evaporation. This was in every respect a suicidal policy, as the juice became cold and sour, and just so much additional fuel was necessary to evaporate it, not to mention the resulting inversion. After this practice had been abandoned, on such days as I was able to see that a strictly neutral clarification was secured, no inversion was noted in the double effect Yaryan.

The diffusion juices showed the presence of large amounts of starchy substances which should be removed by some method of clarification.

The purity of the sirups was fair and the sirups were grained without trouble in the vacuum-pan. The sugar was boiled to a very fine grain.

This fact, as well as the inexperience of the workmen, and the little attention paid to keeping the hot room at a proper temperature, caused the work with the centrifugals to be slow. The sugar also was heavily washed, and a great deal of the fine grain found its way through the screens of the centrifugals. This accounts for the richness of the first molasses, as well as the rather small yield in first sugars. A screw conveyor and elevator buckets should have been provided to remove the sugar from the centrifugals to the sugar room, instead of the boxes used, which necessitated a large amount of hand labor and waste. In several other instances expensive hand labor was relied upon, where an extra wheel or belt would have answered the purpose. One great source of loss was due to the leaks in the joints of the main steam-line, and to the fact that the steam-pipes were not wrapped. The exhaust steam also was not utilized to the extent that it might have been.

The majority of the workmen were inexperienced, and did not appreciate the importance of their particular tasks. There was a very evident lack of harmony between men and managers, and not the firm control and system which is absolutely necessary for the success of any business, especially where the season is a short one, as is the case with sorghum sugar.

The Orange cane was at its best, as last year, about the middle of October, after a light frost sufficient to kill the leaves. The richness of the cane last year was attributed partly to the dryness of the season. This season was one of the largest rain-fall known in Kansas, and yet the average per cent. of sucrose was 11.98 per cent. and glucose 1.78 per cent., and Brix 18.33 per cent.; while for 1888, the average Brix was 19.39 per cent., sucrose 12.42 per cent., and glucose 2.61; or a glucose ratio of 1 : 6.73 in 1889, against a ratio of 1 : 4.76 sucrose in 1888.

This is very interesting and important, especially when the almost exactly opposite character of the two seasons is considered. The seed from last year's crop had been carefully hand-picked and thrashed from the richest plots of last year, and from this source Medicine Lodge and Attica works obtained most of their seed. For this reason, we insert here for purposes of comparison means of Tables I and II from last year's report (Bulletin 20, pp. 83 and 85):

Means.	Solids (Brix).	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Table I.	18.35	12.14	2.35	65.78
Table II.	19.39	12.42	2.61	63.84

Table I.—Juices from single cones.

Table II.—Juices from chips entering battery.

In this connection it is especially interesting to note the results obtained from Amber cane. The seed was selected from a plot which last year showed a Brix per cent. of 18.81, sucrose 14.09, and glucose 1.26,

Very matured Amber grown upon sod land from this seed showed Brix 17.93 and sucrose 13.10; and upon plowed land Brix 18.28, sucrose 13.20 per cent., and glucose 1.29 per cent. In all cases there was a decrease in total solids as compared with last year and there was a corresponding increase in the purity of the juices. We noted again this year, as well as last, that while the Amber cane deteriorated rapidly if left lying any length of time after being cut, the Orange after it had attained its maximum was fairly stable. Again, several hard freezes and thaws did not materially injure the cane, as can be seen from analyses *a*, *b*, *c*, *d*, and *e*, Table I.

The factory was forced to stop cutting, for reasons which will be mentioned later on, the 8th of November. About 600 acres of cane of excellent quality were left standing in the field, so that on this score the mill might have run until the 1st of January, as from reports I have learned that the weather has been excellent in every way. About November 4 there was a light fall of snow, but as already mentioned without danger to the cane.

A number of varieties of seed were sent out by the Department to be planted for experimental plots. The ground upon which it was planted was a very wet piece of sod land, consequently a great deal of the seed did not mature, and as the plots had not been properly separated or attended to, it was deemed best to condemn the whole.

The total number of day's actual work, counting each day at twenty-two hours, was forty-five; that is, the work should have been done in that length of time if the mill had run fairly smoothly.

The expense for labor and coal was enormous, and might have been greatly reduced with proper care. In summing up the results, then, of this season's work, it is but fair to mention that the expense for labor and coal would scarcely have been a cent more if the mill had run steadily and done four times the work than it was with but little work.

In a trial run, beginning on the 26th of October and continuing until the 2d of November, the following data were obtained:

	Sample No.	Brix (corrected) at 17° 5 C.	Sucrose.	Glucose.	Purity.	Glucose to 100 parts sucrose.
			<i>Per cent.</i>	<i>Per cent.</i>		
Chip juices	824	18.29	12.81	1.13	70.03	8.86
Diffusion juices	826	10.00	6.87	.74	68.70	10.80
Mill juices from exhausted chips	813	2.28	1.01	.....	41.84	.....
Clarified juices	827	10.34	7.13	.86	68.95	12.06
Semi-sirup	820	44.56	32.37	3.83	72.64	11.83
First massecuite		89.81	65.60	8.33	.....	12.69
Molasses		78.29	48.40	10.64	61.82	21.98
Second massecuite ¹		84.70	52.10	12.60	.....	24.18
Second molasses ¹		78.10	40.00	13.44	51.21	33.60

¹ From first molasses of trial run.

The mean percentage of fiber, as determined in the chips, during the season was 11.49. Twenty-four determinations were made, extending

over the entire season, from September 5 to November 7. From August 29 to October 3, twenty-six analyses of cane chips, representing the mean composition of the chips entering both batteries, were made. The mean results obtained were as follows :

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	18.10	11.39	2.20	62.92
Highest	21.07	12.98	4.02	.....
Lowest	16.86	8.97	.91	.....

Separate analyses were made of the chips entering the two batteries after August 4, with the following results (the results of eighteen analyses, representing the material entering the old battery from August 4 to November 8) :

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	18.53	12.27	1.38	66.29
Highest	20.40	14.60	3.15	.....
Lowest	16.23	9.00	.54	.....

In the new battery during the same period seventeen samples were analyzed, with the following results :

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	18.36	12.28	1.52	66.89
Highest	20.40	13.65	3.65	.....
Lowest	15.98	10.00	.90	.....

The means for the whole season of all the analyses made of the fresh chips are as follows :

	<i>Per cent.</i>
Total solids.....	18.33
Sucrose.....	11.68
Glucose.....	1.70

The data obtained in the analyses of the diffusion juices from the old battery from August 29 to November 2, including 38 analyses, are as follows :

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	9.81	6.09	1.04	62.08
Highest	12.35	9.06	1.87	73.36
Lowest	8.27	5.00	.52	49.42

For the new battery the data follow. Thirty-eight analyses were made from August 28 to November 8.

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means.....	9.99	6.50	1.03	65.06
Highest.....	12.00	8.26	2.38	75.26
Lowest.....	8.38	5.25	.52	51.02

The analyses of waste chips from the old battery for the entire season gave the following data. Total number of analyses made, 54.

	Total solids.	Sucrose.
	<i>Per cent.</i>	<i>Per cent.</i>
Means.....	2.27	1.13
Highest.....	5.83	2.40
Lowest.....	1.11	.25

In the new battery the numbers follow. Number of analyses, 63.

	Total solids.	Sucrose.
	<i>Per cent.</i>	<i>Per cent.</i>
Means.....	2.16	.89
Highest.....	3.58	1.98
Lowest.....	1.02	.19

Analyses of the clarified juices for the entire season from both batteries gave the following data. Number of analyses, 47.

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means.....	10.25	6.66	1.05	64.97
Highest.....	12.28	8.20	2.07	73.23
Lowest.....	8.74	5.00	.45	50.36

Analyses of the sirups for the entire season gave the following data. Total number of analyses, 45.

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means.....	44.16	29.18	5.19	66.08
Highest.....	55.46	40.37	9.73	84.24
Lowest.....	34.82	19.38	3.18	54.11

Analyses of the first massecuites for the entire season gave the following data. Total number of analyses, 19.

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Means.....	90.27	57.86	12.23
Highest.....	93.34	66.60	23.92
Lowest.....	84.68	50.20	8.38

The analyses made of first and second sugars follow:

POLARIZATION OF FIRST SUGARS.

Date.	Sucrose.
	<i>Per cent.</i>
Sept. 23	95.8
Sept. 23	97.6
Oct. 7	97.0
Oct. 7	97.0
Oct. 7	94.0
Oct. 22	94.4
Oct. 22	96.0
Oct. 29	96.8
Nov. 4	96.8
Nov. 11	95.2

POLARIZATION OF SECOND SUGARS.

Date.	Sucrose.
	<i>Per cent.</i>
Nov. 11	¹ 91.6
Nov. 11	² 94.4
Nov. 15	¹ 88.0

¹Raw sugar.

²Washed sugar.

ATTICA.

ABSTRACT OF REPORT OF OMA CARR.

On the opening of the manufacturing season, on the 26th of September, there was not a sufficient quantity of Early Amber cane ripe, and so Orange cane which was not mature was used from the 8th to the 20th of September. The quality of the cane worked continued to improve until late in the season. In regard to the character of the crop for the successful manufacture of sugar the season may be said to have extended only from September 25 to November 5. After November 5 the cane suffered rapid deterioration, rendering it extremely difficult to work it in the battery without serious loss by inversion. Freezing weather first occurred on the 3d of November, and this being followed by warm weather caused fermentation. The cane which had been planted on freshly turned sod suffered the least from the freeze and showed but little fermentation before the 10th of November.

In recapitulation it may be said that until September 25 the cane was in poor condition, that the indiscriminate mixing of Amber and Orange cane, which became unavoidable, was very unsatisfactory and that all the results obtained before the 25th of September were of little value except for the testing of the machinery.

SOURCES OF LOSS.

From the cutter and the centrifugal there were many opportunities for serious loss; fully 35 per cent. of the cane purchased was carried away in the cutters and cleaners. The loss in the battery by poor extraction and inversion was 13.6 per cent. of the entire sugar contained in the cane. In the remaining portion of the work the loss of sugar amounted to 10.9 per cent. of the whole sugar contained in the cane. The aggregate loss amounted to nearly 25 per cent. of the entire sugar in the crop. This immense loss is directly chargeable to defective machinery and largely due to delays in the working of the house. This is illustrated by the fact that during the season of 78 days 7,239 tons of cane passed the house, or 92.7 tons per day.

The financial failure of the factory must be ascribed directly to inefficient machinery; had the factory worked regularly from the 26th of August the receivership of the 19th of October would not have taken place. The numerous experiments conducted at Attica resulted, in general, successfully. The use of filter presses is to be highly commended. The apparatus for drying the sugar was also successfully worked. The attempt to burn the exhausted chips failed because of the crude, expensive, and inefficient apparatus employed in drying them.

The efficient services of Messrs. Watson and Deming did much to prevent the earlier dissolution of the company.

Summary of results of chemical control.

Cane purchased.....	tons..	7,239.00
Cane, diffused, clean.....	do..	4,702.80
Loss in cutting	per cent..	35.10
Loss in cutting	tons..	2,536.20
Loss in cutting	pounds..	5,072,400.00
Juice in clean cane.....	tons..	4,166.70
Juice in clean cane.....	pounds..	8,333,400.00
Juice in clean cane.....	gallons..	11,000.40
Average per cent. juice, clean cane		88.60
Sugar in cane.....	pounds..	875,841.00
Glucose in cane	do..	133,626.00
Sugar available (approximate).....	do..	675,402.00
Sugar present per ton, clean cane	do..	186.20
Sugar present per ton, field cane	do..	120.00

Losses.

At battery—	Losses.	Clean cane per ton.	Field cane.	Whole sugar.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per cent.</i>
In extraction (total).....	105, 156	22. 3	14. 5	12. 00
By inversion (total).....	14, 341	3. 0	1. 9	1. 63
At double effect (total).....	60, 000	12. 7	8. 2	6. 85
Battery to double effect (total).....	35, 377	7. 5	4. 8	4. 04
Totals.....	214, 876	45. 5	29. 4	24. 52

Yield.

Sugar obtained (firsts)	pounds..	262, 038
Sugar in cane.....	per cent..	29. 91
Sugar in diffusion, juice.....	do.....	34. 64
Sugar in semi-sirup.....	do.....	39. 64
Sugar obtained (firsts)		262, 038
Sugar obtained in semi-sirup		660, 965
Sugar left in molasses		398, 927
Glucose left in molasses (estimated)		128, 539
Available sugar in molasses (estimated)		206, 127
Total product first sugar, plus estimated seconds available	pounds..	468, 165
Yield per ton, field cane, firsts		36. 5
Yield per ton, clean cane, firsts	pounds..	55. 7
Yield per ton, field cane (estimated) seconds	do.....	28. 6
Yield per ton, clean cane (estimated) seconds	do.....	43. 8
Yield per ton, field cane, total product		65. 1
Yield per ton, clean cane, total product		99. 5

Financial.

Cost of cane (7,184 tons)	\$10, 653. 40
Cost of labor (sixty days)	9, 857. 58
Cost of fuel.....	2, 791. 32
Total expense of operation, August 24 to November 12.....	23, 302. 30
Fuel, cost per ton, cane	. 38
Labor, cost per ton, cane.....	1. 48
Cane, cost per ton	1. 38
Total cost per ton, cane	3. 24
Fuel, cost per 100 pounds, sugar.....	1. 06
Labor, cost per 100 pounds, sugar.....	3. 37
Cane, cost per 100 pounds, sugar	4. 06
Total expense per 100 pounds sugar	8. 49
Coal per 100 pounds sugar.....	pounds.. 905
Average labor per day (sixty days).....	\$140. 28
Loss of time by delays in manufacture, season of twenty-eight days, per cent	18. 20

Mean results of analyses.

[In the juice.]

	Total solids.	Sucrose.	Glucose.	Clean cane worked.	Sugar in cane.	Glucose in cane.
Fresh chips entering battery—	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Tons.</i>	<i>Pounds.</i>	<i>Pounds.</i>
From August to September	15.96	9.95	2.29	2,197.2	321,942	75,850
In October	17.72	12.69	1.51	1,914	426,952	43,972
In November	17.41	12.13	1.36	591.6	127,347	13,804

RECAPITULATION FOR THE SEASON.

Total tons clean cane worked for season.....	4,702.8
Average per centage of juice in cane.....	88.6
Total sugar in cane.....pounds..	875,841
Total glucose in cane.....do....	133,626
Total available sugar (approximate).....do....	675,402
Sugar per ton of clean cane (means).....do....	186.2

Sucrose in exhausted chips for the different periods of the season.

	<i>Per cent.</i>
August and September.....	.63
October.....	1.57
November.....	1.46
The season.....	1.46

Sugar inverted in the battery for the different periods of the season and for the entire time.

	<i>Per cent.</i>
August and September.....	.30
October.....	.14
November.....	.20
The season.....	.21

Composition of the diffusion juices for the different periods of the season.

	Total solids.	Sucrose.	Glucose.
August and September....	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
October	12.05	7.60	1.91
November	13.39	8.48	1.13
.....	12.88	8.89	1.07

Composition of sirups.

	Total solids.	Sucrose.	Glucose.
August and September	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
October	52.3	32.5	9.1
November	53.6	36.9	5.1
.....	54.0	36.3	5.5

Mean composition of the massecuites for the season.

	Per cent.
Total solids.....	94.90
Sucrose.....	61.74
Glucose.....	12.16

First sugars, mean composition for the season.

	Per cent.
Sucrose.....	98.29
Glucose.....	.83

Molasses, means for the season.

	Per cent.
Total solids.....	85.31
Sucrose.....	39.42
Glucose.....	18.28

RESULTS OF CULTURE EXPERIMENTS.

Early Amber.—Planted on the 2d, 6th, 7th, and 16th of May. The highest per cents. of sucrose from this plot was 12.45, 12.00, 12.80, and 12.95, respectively, and the apparent time of maturing 123 days.

Chinese Cane.—The highest sucrose obtained was 14.90 per cent. on October 14; on November 7 the sucrose was still 13.70 per cent.; the apparent time for maturing 156 to 163 days.

Kansas Orange.—Highest sucrose obtained was 15.35 per cent.; the apparent time for maturing on different plots from 129 to 146 days.

Late Orange.—Highest sucrose obtained was 15.70 per cent.; apparent time of maturing on the different plots from 132 to 164 days.

Early Orange.—Highest sucrose obtained 14.65 per cent.; apparent time for maturing on the different plots from 129 to 163 days.

Early Golden.—Highest sucrose obtained 14.20 per cent.; apparent time of maturing on different plots from 131 to 146 days.

Link's Hybrid.—Highest sucrose obtained 14.70 per cent.; apparent time of maturing on different plots from 131 to 161 days.

Red Liberian.—Highest sucrose obtained 15.70 per cent.; apparent time for maturing on different plots from 131 to 161 days.

White African.—Highest sucrose obtained 14.00 per cent.; apparent time of maturing from 131 to 161 days.

Deutcher's Hybrid.—Highest sucrose obtained 12.96 per cent.; apparent time of maturing from 131 to 163 days.

Waubunsee.—Highest sucrose obtained 10.30 per cent.; apparent time of maturing from 129 to 158 days.

Goose Neck.—Highest sucrose obtained 13.00 per cent.; apparent time of maturing 185 days.

Honduras.—Highest sucrose obtained 10.30 per cent.; apparent time of maturing from 131 to 148 days.

Whiting's Early.—Highest sucrose obtained 9.00 per cent.; apparent time of maturing from 131 to 136 days.

Large numbers of other analyses were made on the culture plots, but

the above composes a summary of all the most important. The complete analyses, together with the analyses made for seed selection, will be kept on file in the Department.

MEDICINE LODGE.

ABSTRACT OF THE REPORT OF T. F. SANBORN.

The chemical work at Medicine Lodge during the first of the season was under the control of Mr. Hubert Edson. Mr. Edson having accepted a position in Louisiana, the latter part of the work was entrusted to Mr. Sanborn, who compiled the tables of analyses for the whole season.

Three hundred and twenty-three miscellaneous analyses were made of selected canes and canes from the field, with the following results:

[In the juice.]

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	16.67	10.21	1.48	61.24
Maxima	22.70	17.33	2.43	85.37
Minima	9.05	1.11	.83	9.90

JUICES FROM FRESH CHIPS.

Forty-nine analyses were made with the following results:

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	16.46	10.44	2.24	63.66
Maxima	19.12	13.45	4.52	77.97
Minima	14.70	8.27	1.03	47.64

Forty-nine analyses of the diffusion juices were made with the following results:

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	11.40	7.13	1.45	62.54
Maxima	14.23	8.89	2.59	70.70
Minima	9.01	5.20	.69	40.97

Forty-nine analyses of exhausted chips were made with the following results:

[In the juice.]

	Total solids.	Sucrose.
	<i>Per cent.</i>	<i>Per cent.</i>
Means	2.09	1.02
Maxima	2.89	1.54
Minima	1.34	.48

Forty-seven analyses of the clarified juices were made with the following results :

	Total solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	12.02	7.85	1.58	65.30
Maxima	14.82	9.42	2.83	79.46
Minima	9.90	5.22	.78	40.21

Forty-six analyses of the sirups were made with the following results:

	Total solids.	Sucrose.	Glucose	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Means	39.89	26.01	5.45	65.40
Maxima	47.97	32.26	8.94	73.31
Minima	27.06	18.12	3.21	51.26

Eleven analyses of massecuites were made with the following results:

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Means	92.16	56.31	18.12
Maxima	94.74	61.92	20.02
Minima	91.99	51.74	14.29

The mean analyses of the first sugars were as follows :

	Sucrose.
	<i>Per cent.</i>
Mean	98.0
Maximum	99.8
Minimum	95.1

The mean composition of the molasses was as follows :

	<i>Per cent.</i>
Total solids	83.33
Sucrose	42.43
Glucose	26.64

Mean composition of second sugars :

	<i>Per cent.</i>
Sucrose	89.7

MEADE.

ABSTRACT OF REPORT OF JOHN L. FUELLING.

On my arrival at Meade, the 23d of August, the sugar-house was but partially finished, with a poor prospect of a supply of water. The cane was short and dry and a very light tonnage per acre. It was rather the exception to find cane with a fully matured head, and in place of the usual black head of amber I found the cane bearing heads partially white and in some cases perfectly white. The differences in the cane made it imperative to have every load tested which was brought to the sugar-house. Most of the cane had also been ruined by a hail storm and in some cases by the grub worms from the larvæ of the lachnosteria. The cane at Arkalon was in a much better condition. So little cane was received from Liberal that a comparison is not made. In some cases analyses showed that cane which had been cut short by the drought so as to produce no head at all, gave a higher percentage of sucrose than cane which to all appearances was matured. This peculiarity is shown by comparison of three samples of cane, of which the first was a matured Orange cane with fully developed head, the second a sample of the same variety of cane in which the seeds were still in the milk, and the third a sample of the same variety of cane which had developed no seed head at all.

Serial. No.	Brix.	Sucrose.	Glucose.	Fiber.	Albumi- noids.	Purity.
	<i>Per ct.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
1.....	19.72	13.35	2.35	8.73	.7750	67.18
2.....	23.88	18.08	1.81	10.51	1.8000	75.71
3.....	21.49	15.34	2.31	12.32	1.0312	71.38

It was thought a sufficient supply of water could be had by boring an artesian well, but this was proved to be a mistake. After much delay a very deep, large well was dug which furnished a moderate supply of water. There was similar trouble at Arkalon, making it necessary to lay a line of pipe to the Cimarron River. The factory at Liberal was supplied by two artesian wells. The incomplete condition of the works made it impossible to start them until the season was practically at an end, giving them only a little over a week for actual work. The double-effect pan was the source of much trouble and loss; the compartments being entirely too low, the juice on boiling would pass into the coils of the next effect and out into the ditch. The poor extraction in the battery was chiefly due to the coarse chips. The ensilage cutter gave entire satisfaction, doing all that could be desired.

Only one strike of sugar was made at Meade and Arkalon and two at Liberal. The work being of such short duration it was impossible to get a desirable system of control.

There was also no attempt to observe that economy which is necessary to make a success of the sorghum industry. Skimmings showing 5.25 per cent. of sucrose were thrown into the ditch; it was only when, as a last resource, I appealed to the president of the sugar company, I was promised that this loss should be corrected.

According to instructions, I visited the Minneola Sugar Works, where the roasting process was on trial several times, but never succeeded in getting any information nor samples, inasmuch as the works were invariably shut down on my arrival.

Many hundreds of analyses of cane were made, and the following are the averages of some of the most important varieties:

Averages of special canes.

[In the juice.]

Marked.	Varieties.	Sucrose.	Purity.
		<i>Per cent.</i>	
1.....	Cane grown on an up-land	8.34	52.14
2.....	Cane grown on low-land	10.82	62.91
3.....	Cane grown on gypsum soil, spring plowing....	10.54	58.22
4.....	Cane grown on gypsum soil, fall plowing.....	13.14	65.88
5.....	Cane grown on first year's sod.....	10.77	63.00
7.....	Cane grown on old sod.....	8.68	42.82
11.....	Samples of cane that were pithy and red	5.70	42.88

One hundred and fifty-five analyses of selected cane were made at Meade with the following mean results:

[In the juice.]

Total solids	per cent..	16.29
Sucrose	do.....	9.00
Purity		55.66

Fifty-eight analyses of cane were made at Arkalon with the following mean results:

[In the juice.]

Total solids	per cent..	16.04
Sucrose	do.....	9.14
Purity		56.98

Twelve samples of fresh chips entering the battery at Meade, were examined with the following mean results:

[In the juice.]

Total solids	per cent..	18.02
Sucrose	do.....	10.61
Glucose	do.....	3.85
Purity		58.88

Nine samples of diffusion juice were examined at Meade with the following mean results:

Total solids	per cent..	10.19
Sucrose	do.....	5.60
Glucose	do.....	1.82
Purity		54.95

Thirteen samples of exhausted chips from the battery were examined with the following mean results :

	[In the juice.]	Per cent.
Total solids.....		4.05
Sucrose.....		1.86

Eleven samples of sirups were examined with the following mean results :

Total solids.....	per cent..	47.92
Sucrose	do....	27.89
Glucose	do....	7.62
Purity		58.20

Three samples of massecuites from Meade were analyzed with the following mean results :

Total solids.....	per cent..	92.36
Sucrose	do....	56.66
Glucose	do....	13.52
Purity		61.21

Three samples of sugar were analyzed with the following mean result:

	Per cent.
Sucrose.....	93.60

Three samples of molasses were examined with the following mean results :

Total solids.....	per cent..	81.16
Sucrose	do....	38.61
Glucose	do....	16.12
Purity		47.67

NESS CITY.

ABSTRACT OF REPORT OF K. P. MC ELROY.

No sugar was made by the Ness County Sugar Company, a fact wholly attributable to the poor quality of its crop. The mill was started September 26, and was operated at intervals until October 15. The water supply was wholly inadequate for a sugar-house, and although but little work was done there was not enough water to supply battery, triple effect, and strike pan simultaneously. Out of 1,500 acres planted in sorghum there was scarcely enough to supply the mill ten days had it been running full capacity.

The cane entering the mill was even of worse quality than shown by the means of the analyses given. No care was exercised to insure prompt delivery of cane after cutting, and in many cases it lay several days in the field. After reaching the cane platforms affairs were not much better, for the incessant stoppages incident to complete and operate the mill simultaneously caused the cane to lie indefinitely on the platform.

The seed was purchased at Sterling, 100 miles east, but the soil and climate of the two places are radically different, and while the crop at Sterling was fine the crop at Ness City was a failure.

One hundred and ninety-five analyses of single canes and samples of cane from the field were made, showing percentages of sucrose ranging from almost nothing, viz: .10 per cent. to cane of fair quality, in one instance 15.23 per cent.

The fresh chips, exhausted chips, and diffusion juices entering the battery and representing fairly the cane manufactured, had the following composition on the dates mentioned:

Analytical Data.

Date.		Brix.	Sucrose.	Purity.	Glucose.	Ratio.
		<i>Pr. ct.</i>	<i>Per cent.</i>		<i>Per cent.</i>	
Sept. 26	Fresh chips.....	18.67	8.38	45.06	5.32	59.40
Sept. 26	Exhausted chips.....	4.51	1.82			
Sept. 27	Fresh chips.....	17.79	6.94	39.14	5.22	75.22
Sept. 27	Diffusion juice.....	8.55	3.22	37.68	2.73	84.78
Sept. 27	Sirup.....	53.19	19.92	37.45	20.19	101.35
Sept. 27	Exhausted chips.....	1.01	.77			
		Extraction 88.90 per cent.; dilution 110.4 per cent.				
Sept. 28	Fresh chips.....	18.41	8.10	44.00	3.13	38.64
Sept. 28	Diffusion juice.....	9.61	3.92	40.79	3.09	79.59
Sept. 28	Exhausted chips.....		.85			
		Extraction 89.50 per cent.; dilution 91.50 per cent.				
Sept. 29	Fresh chips.....	16.71	6.66	39.86	5.08	76.28
Sept. 29	Exhausted chips.....		.60			
		Extraction 91.00 per cent.				
Sept. 30	Fresh chips.....	17.70	6.68	37.74	6.46	96.70
Sept. 30	Diffusion juice.....	10.04	3.87	38.55	3.94	101.80
Sept. 30	Clarified juice.....	9.53	4.23	44.39	4.19	99.05
Sept. 30	Exhausted chips.....	1.52	.32			
		Extraction 95.21 per cent.; dilution 76.2 per cent.				
Oct. 1	Fresh chips.....	15.71	5.46	34.75	6.41	117.40
Oct. 1	Diffusion juice.....	10.61	3.74	35.25	4.43	118.45
Oct. 1	Sirup.....	47.04	16.45	34.97	20.26	123.16
Oct. 1	Exhausted chips.....	2.03	.48			
		Extraction 91.21 per cent.; dilution 48.1 per cent.				
Oct. 10	Fresh chips.....	14.07	3.66	26.02	6.44	175.95
Oct. 10	Diffusion juice.....	10.36	3.12	30.12	4.49	143.91
Oct. 10	Clarified juice.....	9.96	3.07	30.83	4.39	143.00
Oct. 10	Exhausted chips.....	2.03	.22			
		Extraction 93.99 per cent.; dilution 35.8 per cent.				
Oct. 11	Fresh chips.....	14.81	5.47	36.93	5.77	105.49
Oct. 11	Diffusion juice.....	10.39	3.20	30.80	3.07	95.94
Oct. 11	Clarified juice.....	9.57	2.86	29.82	2.72	95.11
Oct. 11	Sirup.....	35.30	12.50	35.41	19.67	157.30
Oct. 11	Massequite.....	81.50	23.30	28.59	33.33	143.05
Oct. 11	Exhausted chips.....	3.08	.93			
		Extraction 83.00 per cent.; dilution 42.5 per cent.				

METHODS OF IMPROVING SORGHUM.

ABSTRACT OF REPORT OF A. A. DENTON AND C. A. CRAMPTON.

STERLING, KANS.

It has been proven by the thousands of analyses of sorghum juices which have been made by the Department of Agriculture, that sorghum canes often contain a fair percentage of crystallizable sugar, sometimes as much as tropical sugar-cane, or as the improved sugar-beet. It has also been shown that similar canes grown under apparently similar conditions often contain but little sugar, and that sorghum canes are variable in quality.

One object of this experimental work has been to determine the causes of this variableness, and to determine whether the cane can be bred up to uniformly good quality.

There are two classes of plants which can be improved with difficulty. One of these classes consists of plants which are of fixed types, in which the individual plants vary but little, and which readily revert to the original type. The other class consists of plants which are so variable that they can with difficulty be reduced to fixed types having uniform qualities. As sorghum is a variable plant, its improvement implies that it should be bred to certain fixed types which will have uniform qualities.

The lines in which the improvement of the plant should be carried out were laid down by us in Bulletin No. 20, as follows:

(1) By growing and testing all known varieties and selecting the most promising.

(2) By hybridizing or crossing these varieties.

(3) By preserving "sports" or variations.

(4) By selecting seed from the finest individual canes of each variety.

(5) By improved methods of cultivation.

All of these methods were practiced to a greater or less extent in the work in 1888, and this season's work has been practically a direct continuation of the first years work, with such modifications as were suggested by the experience of one season. The results and conclusions attained in each direction will be set forth in the order given above.

1.—EXPERIMENTS IN GROWING DIFFERENT VARIETIES OF CANE.

The first step in this work is the collection of varieties of sorghum from all countries where sorghum is grown, and a comparison of the qualities of the canes. After this has been done there are difficulties in the way of selecting the best varieties. It is well understood by horticulturists that plants sometimes gain, sometimes lose, by a change to new conditions of soil and climate; they require time to adjust themselves to new conditions. It is also well understood by agriculturists that a certain variety of a plant may excel all other varieties in one season, and yet may be excelled by other varieties in another season.

These variations are caused partly by known and partly by unknown causes, some of which may be beyond the control of the agriculturist.

Judged by the average results of a term of years it may be decided that a certain variety is pre-eminently suited to one section of the country. If the results of one season's trial of a variety are good it is encouraging, but it requires confirmation.

When the beet-sugar industry began it met the same difficulties in selecting the best varieties. The common beet was found wild along the coast of the Mediterranean, species were found in Western Asia and in Northern Africa. These varieties differed in form, in color, in size, and in sweetness. Some contained but 2 per cent. of sugar and cor-

responded to the non-saccharine varieties of sorghum. It was found that the white Silesian variety contained most sugar and least impurity. This variety was selected, and from it the best improved varieties of the present day have been developed. This selection of the best variety and the development of improved varieties required time, and occasioned the remark, "The beet-sugar industry began 140 years ago, and for half of that time no one could make it pay."

RESULTS OF TWO SEASONS' WORK APPLIED TO THE WEEDING OUT OF INFERIOR VARIETIES.

All the varieties grown last year, whether they had done well or not, were planted again this year. Even two years' growing of a variety is not fully conclusive as to its merits, and observations extending over a term of several years would be required to determine absolutely that a variety was decidedly inferior and incapable of rapid improvement; yet the varieties of sorghum are so numerous, and differ so widely in their qualities, that it would seem a waste of time to adhere longer to varieties that had shown uniformly poor qualities for two years in succession. We would therefore recommend, in case of a continuance of this work, that such varieties be thrown aside and attention concentrated on the numerous varieties which have shown good qualities during both seasons at this station, and to those varieties which have shown marked excellence at least one season in some particular direction, though not in all, with the expectation that they might be improved in the qualities where they were still lacking, by some of the methods of improvement.

CONTRAST BETWEEN THE CHARACTER OF THE GROWING SEASONS OF 1888 AND 1889.

While the work at this station has only been continued over a space of two years, the diversity of climatic conditions existing during these seasons has contributed greatly towards making a fairly complete test of the relative merit of different varieties. The season of 1888 at this point was exceptionally dry and hot; the season of 1889 was just the reverse—exceptionally wet and cold. The growth of the cane was consequently very different. In 1888 it made a short growth; the amount produced to a given area of ground was small and the cane ripened early. In 1889 the growth was very heavy, the amount produced to a given area was nearly twice as great as in the preceding year, and the time of maturing was at least two weeks later. These two contrasting seasons, therefore, constitute a pretty severe test of the different varieties, and such of them as made a favorable showing in both can be pretty safely depended on to have permanent good qualities. Varieties that made a good showing in the one season and not in the other could not properly be condemned, however, as the conditions may have been particularly severe on them. In 1889, for example, the late season did

not permit of the ripening of some of the late varieties before frost, although the previous season the highest analyses obtained were from these same late varieties.

II.—EXPERIMENTS IN HYBRIDIZING OR CROSSING VARIETIES. III.—
EXPERIMENTS IN PRESERVING SPORTS OR VARIATIONS.

After the best of the known varieties have been selected, the next step is the improvement of these varieties, which may be accomplished by causing or promoting variations among them, and thus obtaining new and improved varieties.

The success of the beet-sugar industry is based upon the improved varieties which the beet growers have created. The success of the sorghum industry will be based upon the possibility of procuring improved varieties.

In 1860, when Vilmorin was producing his famous variety of the beet known as the "Improved Vilmorin," he resorted to crossing varieties, and then to selection of seed from the best of the crossed plants. Many of the finest fruits have been crossed and recrossed many times. Then, again, many valuable varieties of plants have originated in so-called "sports" or variations which have suddenly appeared in some unknown way. It is probable that these are often simply accidental or unknown crosses.

In the work at this station the experiments in this direction have been confined to this class of variations, the large number of plots and press of work having prevented experiments in the line of artificially produced crosses.

In the following analyses it will be seen that we have selected many of these variations of unknown origin from among canes of well known varieties; some of them differ from all known varieties of sorghum, some of them have much higher percentage of sugar than the varieties from which they were taken. In fact, these variations are new varieties. It will be remembered that the Early Amber, which is now perhaps the most widely distributed variety of sorghum, is said to have been a chance variation found in a field of the "Chinese" variety, and also that Link's Hybrid, which, if not the best variety for sugar manufacture, is one of the best, originated in a variation found in a field of the Honduras variety.

There is no doubt that remarkable variations in type, in time of maturing, and in quality of juice are produced by crossing varieties, or that permanent new varieties having new characters and qualities may be produced by crossing varieties of sorghum. In many of the lots in the experimental field which were planted with the seeds from a single crossed cane the variations in the qualities of the individual canes were so great that it was not possible to take average samples of cane from those lots which would give comparable analyses. Here is opportunity for the skilled horticulturist to select a single crossed cane of desired character and of unusual percentage of sugar, and to fix its extraordi-

nary qualities by repeated selections, and thus create an improved variety. It is possible to combine the good qualities of two good varieties. Our analyses show that some crosses mature earlier than the late maturing parent varieties, that some have very high percentages of crystallizable sugar, that some have very low percentage of uncrystallizable sugar, that some have high purity of juice, and some give a large yield of cane per acre.

“MIXING” OR ACCIDENTAL CROSSING OF VARIETIES.

The indiscriminate crossing of varieties, caused by seeds of more than one variety being planted together, is, of course, an unmixed evil so far as sugar manufacture is concerned. But our work and observations at this station for the past two years have convinced us that the extent to which such crossing occurs between varieties planted in juxtaposition has been greatly exaggerated.

It has been said that varieties of sorghum will mix across a 40-acre field, and that broom-corn makes sorghum which grows a mile away worthless for sugar manufacture. We have carefully observed the evidences of crossing, and have not yet seen proof that crossing occurs at a considerable distance. It is observed that sorghum does not produce pollen in such profusion as corn. With sorghum there is no necessity for such excess of pollen. It is true with sorghum, as it is with most other plants, that when seeds of two or more varieties are planted together or in close proximity, crossed plants sometimes appear the next season from germs of those seeds which were cross-fertilized the first season. It is easy to understand that seed-tops swayed by the wind may come in contact with seed-tops of other canes. Crossing of varieties, however, is not as frequent as is supposed. We have frequently intentionally mixed thousands of seeds of two varieties and planted them together for the purpose of producing a cross between those varieties, and in the following year we have often found but few, sometimes none, of the thousands of canes produced by those exposed plants to show the desired cross.

The continuous planting for many years of sorghum seeds which have been accidentally cross-fertilized in greater or less degree has, however, produced endless variations in type, in time of maturing, and in quality of ordinary sorghum canes. In many hundred packages of sorghum seeds received at this station from many countries there were but few, if any, in which variations caused by crossing could not be found.

It has also been said that where broom-corn or other non-saccharine varieties of sorghum are extensively grown sorghum cane is worthless for sugar manufacture. It has been said that sorghum canes which grew near a field of non-saccharine varieties contained but 2 per cent. of sugar. It has been said that sorghum growing in France for the production of alcohol from the sugar in the canes was abandoned on account of the deterioration in the quality of the canes produced by

crossing with broom-corn.¹ But it is not possible by any known means to modify the character of any plant at any period of its growth after the germ which produces that plant has been formed. The germ of the seed contains the destiny of the plant. If the history of the germ is known, the character of the plant which it produces is also known.

Circumstances may modify the development of the plant, but they can not change the type or the nature of the plant. Sorghum seed of pure variety planted with broom-corn or other non saccharine varieties produces as good canes with as high sugar content as if planted alone. The germs of the seeds produced by these canes may, however, be fertilized with pollen from the non saccharine varieties, and the plants of the second generation may thus be worthless for sugar manufacture.

It follows from these facts that when pure sorghum seed is planted each year it is immaterial what varieties are grown in the adjacent fields, but the seed for the succeeding year should not be saved from such fields, but a fresh supply should be procured from a seed farm or establishment for the production of pure seed. In such an establishment, of course, all doubt in regard to the purity of the seed should be removed by making continuous selections of seed from year to year, and by planting the selected seed in widely separated lots, as is done in growing "special" beet seed for sugar manufacture. Unfortunately it has not been possible to do this with the seed raised at this station so far, and we are unable to guaranty absolutely the purity of the varieties. The facilities and allowances have been so meager and the range of the work so extended that sufficient space could not be given the different plots. We have had to determine the qualities of all the varieties, to study the tendencies of selection and of crossing, and to learn the methods of improving the sorghum cane. It has not hitherto been possible to plant four hundred separate packages of seed on four hundred separate farms. In continuing this experimental work with a view to the selection of pure seed of the best varieties it is recommended that a much larger area of land be used for this purpose than has previously been used, and that it be land upon which sorghum has not before been grown, so as to do away with the difficulty arising from volunteer cane.

IV.—EXPERIMENTS IN THE SELECTION OF SEED FROM INDIVIDUAL CANES SHOWING A HIGH CONTENT OF SUGAR.

The importance of this method of improvement and the probability of obtaining good results by following it up were set forth in last year's report, but perhaps some further reference to its employment and success in the beet industry will not be amiss. Stammer² speaks of it as follows:

In the last few years the necessity for seed selection from the richest beets has become more apparent. * * * Though this was true in previous times, yet now

¹ Hippolyte Leplay, Bull. 18, p. 180.

² Lehrbuch der Zuckerfabrikation.

more than ever the condition of the factories demands rich beets. * * * While formerly it was sought to accomplish this object by pure breeding of the best varieties, now more prominence is attached to the selection of seed from individual beets of the highest sugar content and purity. * * * It was only after people had learned to select beets for seed first by their outward characteristics, then from these according to their sugar content, that beets were produced which combined excellence of form and of sugar content. * * * In conclusion, it may be said that too great emphasis can not be laid upon the fact that no other branch of the subject deserves greater attention from beet-sugar growers than the planting of the best seed.

In the present condition of the sorghum-sugar industry, and in the undeveloped condition of the sorghum plant, these statements have special force and should have the careful consideration of sorghum-sugar growers.

TIME REQUIRED FOR IMPROVEMENT IN VARIETIES OF SORGHUM BY SELECTION OF SEED

In Bulletin No. 20 attention was called to the advantages possessed by sorghum over other sugar-producing plants in the ease with which seed could be selected from the best individuals by the analysis of the juice.

While an increased yield of sugar may be speedily obtained by a single selection of seed and by separate planting and by careful cultivation, the development of pure-bred seed of improved varieties will require more time.

PROGRESS MADE IN THIS DIRECTION THE PAST SEASON.

Unfortunately we can not report much progress in this line of improvement during the past season. In 1888 the selections of seed heads by analysis from standard varieties covered comparatively a small range of individuals from a few standard varieties only. The work of selection began late in the season, and consequently was confined entirely to the late varieties, such as Liberian, Early Orange, etc. But these late varieties were the very ones that did not mature this season, so it was impossible to determine whether any improvement had been made. With the exception of these late varieties, nearly all kinds of cane made a better showing in analysis this year than last. It was a better season for the development of the sugar content of sorghum cane. The analysis of average samples from plots which were planted from single seed heads that had been selected for some special reason, such as peculiarity of form, and of which the analysis was known, shows almost invariably a higher analysis than the cane from which the plot was planted. This improvement could not be attributed to selection for a single season, but was due to the better growing season, as already stated.

This year more work was accomplished in the selection of fine indi-

vidual canes from standard varieties, and a better foundation was laid for the prosecution of this method of improvement in future years. Nearly every variety which showed good general results was subjected to selection of individuals by analysis, and a large number of seed heads obtained, with a high "record" for one season. It is not to be expected that the canes produced from these seed heads next year will necessarily show higher, or even as high analyses as the parent cane from which they came. Next season may be as exceptionally bad as this season was exceptionally good for the production of fine canes. Even if the seasons are equal in this respect, it will not show that the plant can not be improved in this direction.

It is not reasonable to suppose that seeds from a cane of extraordinary quality will produce canes of as extraordinary quality as the parent cane, for this implies that a greatly improved variety can be produced by a single selection. A gradual and general improvement, after selections extending over several years, is all that could reasonably be expected.

IMPORTANCE OF PLANTING SEED WHICH WILL PRODUCE CANES WITH A UNIFORM TIME OF RIPENING.

Independently of the matter of improving varieties of sorghum by selecting seed from the best individual canes, it seems to be clearly proved by the experimental work that very great improvement in the yield of sugar may be made by selecting and planting together those seeds of a variety which mature at one time.

In all ordinary fields of sorghum it is noticed that all the canes of one variety and of one planting do not mature at the same time even if the variety is pure and unmixed with other varieties; they vary in maturing from two to four weeks. These differences in time of maturing are almost sufficient to account for the considerable differences in sugar content which are found in the individual canes in one row of one field. It is well known that immature canes, and also over-ripe canes whose juice has deteriorated, have a low percentage of crystallizable sugar and a high percentage of uncrystallizable sugar. In practical work it is not possible to harvest only the canes which are in their best state, and thus, although the individual canes in a field have, or have had, or would have if left longer to mature, a fair percentage of sugar, yet the average yield of sugar from all the canes harvested at one time will be small. It follows from these facts that although sorghum seed may seem pure and unmixed with seed of other varieties, yet if it contains subvarieties which mature at different times this will lessen the yield of sugar, for there will be differences in degree of maturity, and consequent differences in sugar content in the individual canes, and the average yield of sugar will be low.

PLOTS PLANTED FROM A SINGLE SEED HEAD.

The advantage of raising canes with a uniform period of ripening was beautifully illustrated in the experimental field this season by the plots which had been planted from a single seed head of a pure, well-established variety. The canes in such plots, without exception, came up, and grew and ripened with a remarkable degree of uniformity. The tops of some plots were like level floors, and there was probably not a week's difference in time of maturity amongst the individual canes. The canes were uniform not only in time of maturing, but also in type and in analysis. In plots planted with seed taken from a general lot, on the other hand, the differences in type, in time of maturity, and in analysis were apparent even to the unobservant.

If now it were possible to plant an entire field with the seed from a single cane, and thus secure the same degree of uniformity we obtained in our small plots, nothing better could be desired. This can not be done, of course, but it is reasonable to suppose that seed heads selected from such a uniform collection as our plots would produce a field of cane in which the individuals would approximate closely in maturity and in type, even though they came from different seed heads. A single seed head will plant a pretty large area of ground, and from the cane it produces enough can be selected the second year to plant a large field.

If for no other purpose than to secure this essential uniformity, we would recommend sorghum growers to obtain their seed for planting in this way: To obtain a single seed head from a good and pure variety, from which it has been selected for exceptionally good results on analysis. This will correspond to the "mother" beet in beet culture, and the seeds from this head should be planted in a separate plot and all possible precautions taken to prevent their being contaminated or cross-fertilized from other canes. Uniformity should be further secured by care in cultivation, and even covering, so as to secure an equal chance for all, and there is little room for doubt that the seed from these canes will produce a field of exceptional evenness of type, of time of maturity, and of sugar content.

We regard this method of "family breeding" as the best calculated to overcome the variableness of sorghum and to produce fixed types of uniform qualities.

If one thousand canes are taken from one variety on the 1st of September and examined separately, and if from these three or four seed heads are selected from the canes which contain most sugar, then it is evident that while selecting canes of unusual quality selections are also made of canes which mature at that date; and if on the 1st of October one thousand canes are again taken from the same plot, and if from these similar selections are made, then it is evident that while selecting canes of unusual quality, selections are also made of canes which ma-

ture a month later than the first selections. The mixture of seeds from these subvarieties which mature a month apart is especially to be avoided; it nullifies the effort to produce canes which ripen at the same time. Selections by analysis, made when the plot on an average is immature, picks out the early ripening canes; selections made when the plot on an average is over ripe, rejects all but the late ripening canes. In order to have the selection based as much as possible upon relative good qualities of the canes, such work should therefore be done as nearly as possible when the greater part of the whole plot is at the maximum of maturity, and this is made much easier if the plot is itself fairly uniform.

Early selections may of course be practised in an endeavor to improve a variety in early ripening. It is evident that both earlier, and also later maturing subvarieties of sorghum may be formed by continued selections of early or of late maturing canes from one variety; the effect of early, and also of late selections from the late maturing Honduras variety will be seen in the analyses of different plots of that variety. Where a variety is to be maintained in its integrity and normal condition, however, selections from it should be made only at one time, and that time when it is neither under nor over ripe.

Another argument in favor of "intensive breeding," that is, taking a single seed head as a starting point, preserving the succeeding generation intact, and endeavoring to promote uniformity amongst canes in the plot, may be found in the fact that analysis may not give a proper indication of the quality of the seed of the cane analyzed, if cross-fertilization has taken place between it and neighboring canes. Suppose, for example, that a cane is selected by analysis from a plot in which there is not much uniformity among individuals; the simple fact that it had been selected on account of its very high analysis would imply that the canes around it were much inferior. If its seeds have been fertilized by pollen from any of these inferior neighbors, they will be just as likely to transmit their inferior qualities as the good qualities of the parent stem, and the high analysis of the latter would therefore be no guaranty of the quality of the seed taken from it. Were the parent stem surrounded by individuals of as high, or nearly as high quality as itself, this danger would be avoided.

V.—EXPERIMENTS IN IMPROVEMENT BY METHODS OF CULTIVATION.

The methods of cultivation employed at this station have been perhaps sufficiently set forth by us in our previous report. We can only emphasize the necessity of care in following the details of the directions given, and would desire, as evidence of the correctness of our method and of the good results which can be obtained by careful cultivation, to call attention to the many fine plots of cane raised at this station the past season.

It is difficult to make apparent on paper the good quality of these plots,

for the analyses do not show the handsome appearance and fine growth of the cane, or its uniform ripening and even character. Some indication may be had, however, from the following table, giving the yield per acre of a few plots, obtained in a manner to be described later on :

Variety.	No. of pot.	Yield per acre.
		<i>Tons.</i>
Planter's Friend.....	186	19½
Do.....	376	26½
Ubehiana.....	226	21½
Plot No. 24 (1888).....	227	28½
Plot No. 14 (1888).....	228	18½
Late Orange.....	239	21½
Do.....	386	22½
Underbule.....	254	18½
Plot No. 52 (1888).....	258	21½
Early Orange.....	382	29
Honduras.....	115	24
Do.....	383	33½

This list includes only a few plots which were standing nearly intact at the close of the season, and the yield in many others was fully as high. Yet, notwithstanding the heavy growth, the sugar content was very good, the cane was uniform, and the analyses of average samples corresponded well with one another. There could be no question whatever of successful sugar manufacture from fields of such cane, and we see no reason why large fields of similar cane should not be produced as well as small ones by the same care in planting and cultivation.

DETERIORATION OF SORGHUM AFTER BEING CUT.

It is unfortunate that canes rapidly deteriorate, if they remain long unworked after being cut. This fact adds greatly to the difficulties of sorghum sugar manufacture. In practical work, unavoidable losses occur from the rapid deterioration of the canes. It is probable that there are considerable differences in the varieties in their keeping qualities, but we are not aware that any experiments have yet been made to determine their relative keeping qualities and it may be well to call attention to this point. It is reasonable to suppose that sorghum cane of an improved variety, having high purity and 20 per cent. of sugar will deteriorate less rapidly than sorghum cane which has low purity and but 10 per cent. of sugar.

The various experiments that are on record in respect to the loss of sugar in siloed cane also, would seem to indicate very marked differences in the keeping qualities of different varieties. Professor Cowgill, for example, in October, 1884, buried one ton of Link's Hybrid, and one ton of Orange cane, covering with three inches of soil. The canes were taken up and analyzed in the following January, and his conclusion was that the Link's Hybrid canes had sustained no loss of sucrose by being buried three months, while the Orange canes had lost nearly 5 per cent. A similar experiment made at this station may be given a place here as a contribution to the study of this point. On October 19

5 tons of cane were taken from a plot of Early Orange, and the same amount from a plot of Late Orange; the canes were covered in a very simple and expeditious manner by throwing a furrow from each side upon the cane laid lengthwise along the row. On December 2 the buried cane was taken up, passed through the large five-roller mill of the Sterling Sirup Works, the juice from the entire 5 tons of each variety collected in separate tanks and analyzed, together with analyses of the juice from an average sample of cane from the same plots, taken just before the plot was cut up, and passed through the small hand-mill.

Before burying, October 19.					After being taken from silo, December 2.			
	Brix.	Sucrose.	Glucose.	Co-efficient of purity.	Brix.	Sucrose.	Glucose.	Co-efficient of purity.
	°	<i>Per cent.</i>	<i>Per cent.</i>		°	<i>Per cent.</i>	<i>Per cent.</i>	
Early Orange.....	15.64	10.87	2.11	69.50	16.80	9.62	2.75	57.30
Late Orange.....	16.34	11.56	1.80	70.74	16.20	9.23	2.66	57.00

The analyses show a loss of sucrose in the Early Orange of 1.25 per cent., and a gain of .64 per cent. of glucose; and in the Late Orange a loss of 2.33 per cent. of sucrose, and a gain of .86 per cent. of glucose. The purity was much less after siloing in both cases. The samples are not so closely comparable as could be desired, the first juice being expressed by a hand-mill, and the second from a large double crusher.

PRESERVATION OF SORGHUM BY THE ADDITION OF SUBACETATE OF LEAD.

A portion of each of the large samples of the juice from buried canes mentioned above was preserved by the addition of a small quantity of subacetate of lead, and sent to the laboratory at Washington for analysis. A comparison is made of the analyses made at this station and at Washington in the following table:

EARLY ORANGE.

	Brix.	Sucrose.	Glucose.
	°	<i>Per cent.</i>	<i>Per cent.</i>
Analysis made at the Sterling Station.....	16.80	9.62	2.75
Analysis of same juice made at Department laboratory at Washington.....	16.80	9.73	2.19

LATE ORANGE.

	Brix.	Sucrose.	Glucose.
	°	<i>Per cent.</i>	<i>Per cent.</i>
Analysis of juice made at the Sterling Station.....	16.20	9.23	2.66
Analysis of same juice made at Department laboratory in Washington.....	16.20	9.33	2.54

The analysis at Washington was made seven days after the juice had been expressed, but the two analyses agree very closely, and show that the juice had not suffered the slightest deterioration. It is interesting to know that sorghum juice can be preserved for so long a time by lead, and it may prove useful in sending samples some distance for analysis. We have often received at this station samples of cane for analysis, sent by express from remote points. Such samples are generally so much deteriorated by the time they arrive, that an analysis gives but slight indication of their quality. Where access can be had to a mill, it would be much better to express the juice from a considerable quantity of the cane to be tested; collect and mix in a common receptacle; add a small quantity of subacetate of lead to a definite volume of the juice, and send to the laboratory by express. A sufficient quantity of the prepared solution of subacetate of lead can easily be furnished on application by any laboratory equipped for sugar work.

EFFECT OF RAIN ON THE JUICE CONTENT OF SORGHUM.

The analyses of Dr. Collier, in 1883, showed that three days' heavy rain, after a period of drouth, caused a loss of over 3 per cent. of sugar in sorghum canes. In the work here this season it was noticed that, after a week of almost continuous rain, the analyses of the varieties sampled during this period were lowered. As the analyses are based upon the juice, and not directly on the cane, it would seem possible that this apparent loss was due simply to a dilution of the juice content of the canes.

A beginning was made at this station the past season to determine the content of marc in the different varieties, but on account of press of work and lack of assistance it could not be carried out. The following determination would show that considerable range in juice content might be found in such an investigation:

	Per cent.
Marc in cane from plot of a non-saccharine sorghum	27.65
Marc in cane from plot No. 258 (sorghum bicolor)	11.46

The non saccharine varieties are as a rule inclined to be pithy and dry, and it is not likely that saccharine canes would show nearly so high a content of marc as the non-saccharine sample above.

LARGE SEED HEADS INDICATIVE OF SMALL SUGAR CONTENT IN CANES.

It was observed and noted by us last year that in selecting canes by analysis those which were of extra high percentage of sugar had small seed heads. This year's work has confirmed this observation, and it can almost be laid down as an established rule that individual canes having larger seed heads than their fellows have also a low content of sugar, and that varieties producing a large yield of seed do not show as good average analyses as varieties with small seed heads. It was

also observed this season that in the plots which were planted with seed from a single cane of extra quality the canes as a rule had also inherited small seed heads, in some cases not yielding half the usual amount of seed. There were, however, some exceptions to this rule.

In the absence of better means of selection it would seem better for the sorghum-grower to reverse the usual custom of selecting large and fine heads for seed, and select rather good-sized canes which have small seed heads.

It is probable that where improved varieties of sorghum have been produced sorghum will be more a sugar-producing plant, and less a grain producing or cereal plant.

DIFFERENCE BETWEEN VARIETIES IN RESPECT TO THE LENGTH OF TIME THEY RETAIN THEIR MAXIMUM OF SUGAR.

It was said by M. Hardy, director of the Central Government Gardens at Hamma in Algeria, that sorghum canes remained standing in the fields for months after maturity without loss of sugar. M. Bourdais, of Constantine, Algeria, also observed that sorghum canes long retained their value, and the same was said of sorghum by M. Balguerie, of Gualoupe. It will be observed that some new varieties in the experimental field retained their maximum sugar content much longer than is usual with the ordinary varieties. Whether this is due to a very slow ripening of the seed in such varieties and consequent gradual storage of the sugar, or to an inertia of cell growth and consequent gradual re-absorption of the sugar, or to some other cause, are questions that can not be answered in the state of our present knowledge of the physiology of sorghum cane; but these differences seem to be quite constant.

The Early Amber and the White African, for instance, deteriorate rapidly. The Link's Hybrid and some others are much more durable in quality, and it is possible that still more durable varieties may be found.

It is evident that a variety which long retains its sugar would greatly assist the cane grower and the sugar manufacturer, for it allows longer time for working the crop. It has also a very great advantage in that it allows all the canes to ripen before any deteriorate. In selecting a variety this point should be considered. As no one variety of sorghum is so durable in sugar content that a single planting will furnish cane for the entire season, it is necessary to plant varieties which mature at different times, or to make successive plantings of one variety. With late maturing varieties successive plantings are not profitable, for these varieties require the entire growing season to attain their maximum sugar content. It is a problem of no little difficulty for the sugar grower to arrange the planting of varieties or to proportion successive plantings so that the canes will attain their maximum of sugar in sufficient but not in excessive quantities to make a long, continuous run of the factory.

It will probably be found best to plant in addition to the usual early

and late varieties a medium maturing variety, which will come in between the early and the late, and not only fill the gap between them, but also guard against a heavy loss of cane from a very early or very late season.

GENERAL DESCRIPTION OF THE WORK DONE THE PRESENT SEASON AT THIS STATION.

Four hundred and four separate plots were planted this season with seeds of numerous varieties of sorghum, with seeds of selections made last season, and with crosses. The experimental field comprised about 39 acres, being the same ground that was used in last years work. About 100 separate plots were planted in seed selections from canes of unusual quality, or from canes of unusual type; about 100 separate plots were planted in seeds taken from crossed canes, and about 200 separate plots were planted in seeds of the varieties of sorghum.

The planting began April 22, and was continued until July 13. The seeds were planted by hand, covered uniformly with soil to a depth of 1 inch; the planting was done in moist soil, following the plow closely; no thinning out of plants was done, and the stand of cane was almost perfect, except in a few plots in which from unknown causes seed which was apparently perfect failed to grow. The cultivation was deep and close while the plants were small; then deep cultivation was only done in the middle of each row, and when the fibrous roots extended, the cultivation was finished with a one horse harrow having many short teeth, and having the width adjusted, so as to take all the surface in the space between two rows of cane; the surface soil was thus harrowed once each week to a depth of 1 inch after the plants became large, until the canes were 10 to 12 feet high.

Some plots were washed out by flooding rains in the early spring, some were destroyed by chinch-bugs from an adjoining wheat field, and some were blown down by a wind storm in August, but the average yield of cane was very large.

The general plan of the analytical work was essentially the same as last year, which was fully described in Bulletin No. 20.

About 1,500 complete analyses were made from the different plots to determine the value of each as a whole. About 1,900 polarizations were made of single canes for the purpose of selecting seed from those of high sugar content. About 7,000 selections of seed heads were made by the saccharometer alone, of canes whose juice had unusual density. This station has sent in to the Department five tons of sorghum seed, consisting of average seed from the general lot of the different varieties, and 8,600 single seed heads. The latter are carefully preserved, each being tied up separately in a paper bag, and labelled with the name of the variety and number of the plot from which it was taken, and the analysis of its parent cane. Some of these pedigreed seed heads will be retained by the Department for its own use in case this work is con-

tinned under its supervision, and the rest will be distributed amongst the State experiment stations, sorghum sugar factories, and others interested in the improvement of the sorghum plant.

RESULTS OF ANALYSIS.

Owing to the limited space allowed for printing, it was found necessary to greatly curtail the quantity of analytical data to be published in this report. The following tables therefore represent only a small fraction of the work performed. Only one plot of each important variety is represented in the tables, and the plots of less promising and unnamed varieties are cut out, together with those of all except the most promising crosses and variations. All the analytical work has been tabulated, however, and will be preserved at the Department for reference, in order to be able to trace the history of either varieties, or individual cane seed selections. Only analyses of average samples taken from the entire plot are included in the following tables. These samples were taken in the same way as last year, except that a few analyses were made at the end of the season of samples taken as follows:

The near approach of cold weather and one or two heavy frosts having indicated that the season was at an end, such plots as were still in good condition were measured, and all the canes cut from the measured area. The sample of field cane obtained in this way was weighed, and from its weight the equivalent yield per acre was estimated; the cane was then topped and stripped and the whole passed through the large five-roller mill of the Sterling Sirup Works. The juice was retained in a common receptacle, and a sample taken for analysis. The object was to obtain a sample which would correctly represent a large quantity of cane, and also to see how the juice would compare with that of small average samples expressed by the hand-mill. The results show very little difference, and it is evident that the extraction by the large mill did not differ greatly from that obtained by the small mill.

They show also that our manner of sampling was accurate, and gave a good average representation of the entire plot.

FOLGER'S EARLY VARIETY.

[Planted May 4 with seed from a single selected stalk. This variety originated in a selection of a variation from Early Amber, made by A. S. Folger, of Iowa; the canes are larger than Amber, and mature nearly as early.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
205			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
	Sept. 5	29	16.88	12.70	2.11
	Sept. 12	125	17.34	13.72	2.22
	Sept. 13	152	18.93	14.63	2.02
	Sept. 18	242	17.78	13.53	1.81
	Sept. 23	419	18.93	14.23	2.04
	Sept. 25	493	18.64	14.07	2.39
	Oct. 1	677	20.24	15.71	1.65

LINK'S HYBRID.

[Planted May 3 with seed from a single selected stalk. This variety appears to be one of the best, if not the best variety for sugar manufacture. More attention has been paid to it this year than to any other.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
154	Sept. 6	44	16.81	12.45	.99
	Sept. 20	321	17.47	13.37	.88
	Sept. 25	465	18.76	13.94	.69
	Sept. 30	621	19.34	15.15	.74
	Oct. 4	790	19.53	16.34	.55
	Oct. 12	1234	17.38	14.58	.60
	Oct. 22	1311	20.38	15.83	.26
	Oct. 26	1437	16.18	13.00	.53

PLANTERS' FRIEND.

[Planted May 4 with seed from a single selected stalk. A large number of plots was planted with this variety from single seed heads selected last year, but very few attained maturity. Many plots were blown down and tangled by the wind.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
186	Sept. 20	326	18.96	14.07	.93
	Sept. 23	412	18.96	13.52	1.92
	Sept. 25	485	18.66	14.06	1.70
	Sept. 28	574	18.81	13.71	1.80
	Oct. 2	701	19.94	14.75	1.67
	Oct. 7	895	18.70	14.26	1.86
	Oct. 19	1024	19.36	15.29	1.68
	Oct. 19	1269	17.59	14.18	1.11
	Oct. 23	1318	20.46	16.21	.55

HONDURAS.

[Planted May 6, from general lot of seed from last year.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
236	Oct. 7	916	15.60	11.70	1.71
	Oct. 11	1175	16.00	11.09	2.06
	Oct. 25	1404	15.72	13.22	1.89

HONDURAS (EARLY).

[Planted May 1 from a single early-maturing cane selected from Honduras. It is practically a new variety, or rather subvariety.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
119			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
	Sept. 4	21	13.58	8.90	1.54
	Sept. 11	91	13.15	9.01	1.84
	Sept. 14	170	16.58	11.63	2.07
	Sept. 17	227	14.18	9.99	1.34
	Sept. 20	305	15.60	11.59	1.61
	Sept. 26	516	16.88	11.88	1.51
	Oct. 2	692	18.22	13.71	1.09
	Oct. 4	815	16.80	12.62	1.31
	Oct. 8	998	16.74	12.41	1.18

SORGHUM (BICOLOR).

[Planted April 22. The same variety as the unnamed plots Nos. 15, 47, and 52 last year. This variety was remarkable last year for its low glucose content, and this characteristic has remained constant throughout the various plots grown this year. It is possible that such a variety could be improved in its sucrose content without the loss of the good quality it already possesses of a low percentage of glucose.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
70			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
	Oct. 4	822	18.95	13.42	.45
	Oct. 11	1185	19.61	14.45	.61
	Oct. 19	1275	17.69	12.85	.66
	Oct. 25	1387	17.81	13.48	.58

EARLY ORANGE (RIO BLANCO)

[Planted April 22 with seed obtained from Mexico; good canes, apparently the Early Orange, but the analyses are so superior to those of other plots that the name sent with the seeds, "Rio Blanco," is retained.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
107			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
	Sept. 11	88	16.32	12.03	2.43
	Oct. 1	655	17.82	13.44	1.94
	Oct. 4	809	17.90	13.73	1.79
	Oct. 5	884	20.03	17.05	1.69
	Oct. 12	1241	18.80	14.84	1.42
	Oct. 25	1388	18.11	14.18	1.40

EARLY AMBER.

[Planted May 6 with seed from general lot of last year; later than usual in maturing and not quite so high in analysis as last year.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
235	Aug. 30	3	16.62	12.05	1.53
	Aug. 31	6	16.55	11.45	1.30
	Sept. 2	7	15.93	11.75	1.32
	Sept. 3	15	15.50	11.25	1.23
	Sept. 4	18	17.07	12.65	1.07
	Sept. 5	24	15.90	11.90	1.12
	Sept. 6	33	16.60	12.45	1.01
	Sept. 7	82	16.95	12.32	.93
	Sept. 13	132	15.93	11.85	.98
	Sept. 16	193	15.48	11.22	.84
	Sept. 19	283	15.72	11.89	1.00
	Sept. 23	384	16.42	11.81	.94

LATE ORANGE.

[Planted May 6 with general lot of last year's seed.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
241	Sept. 9	70	15.22	10.76	2.66
	Sept. 16	181	15.05	11.17	2.21
	Sept. 19	281	16.50	11.90	2.38
	Sept. 27	545	17.96	14.05	1.74
	Oct. 3	752	18.20	14.82	1.63
	Oct. 7	923	18.69	13.83	1.53
	Oct. 11	1173	20.80	15.71	1.92
	Oct. 25	1407	17.40	13.63	1.43

CHINESE IMPHEE.

[Planted April 22 with seed received from Dr. Collier. This plot was *not* Chinese in type, contained two distinct varieties, one of which may prove valuable.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
14	Sept. 14	163	15.75	11.37	.93
	Sept. 21	371	18.49	13.95	.41
	Sept. 24	442	18.70	14.60	.25
	Oct. 1	650	18.06	13.52	.83
	Oct. 8	949	18.60	15.19	.37
	Oct. 11	1184	18.90	14.24	.88

ANALYSES OF CROSSES AND VARIATIONS.

Following are the analyses of few of the plots planted from crosses or variations selected last year. While all such plots were analyzed to determine their value, no great amount of work was expended except in cases where the uniformity of the plot showed an established, or nearly established, type. There were quite a number of such plots, however, which showed not only an established type, but also an improvement in some directions over the variety or varieties from which it originated. Some showed remarkable qualities on analysis; as, for example, plots Nos. 291 and 293, which gave some of the highest individual cane analyses obtained this season. Many of these crosses seem to be sufficiently well established in type to justify their being designated as new varieties, but probably it will be safer to grow them one more year, at least, from selected heads, to guard against reversion. From our experience with these crosses it would appear that a variation or cross can become established in type within three years after its initial production; that is, from the time the seed germ is impregnated or modified.

All the following plots were planted from single selected seed heads:

AMBER AND ORANGE CROSS.

[Planted May 6. This and three similar plots were all planted from single seed heads selected from plot No. 153 last year. This cross will undoubtedly develop into a valuable new variety. It is a curious and encouraging fact, that the cane showing the highest content of sucrose last year should produce a plot this year (No. 293) from which the highest individual cane analysis of this season was obtained, giving the unprecedented result of 20.72 per cent. sucrose in the juice.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
253	Sept. 6	35	12.68	7.60	2.07
	Sept. 9	60	16.71	7.86	1.30
	Sept. 16	175	17.18	13.61	1.23
	Sept. 19	273	18.87	14.92	1.55
	Sept. 21	364	18.84	14.07	1.03
	Sept. 23	397	19.07	14.64	1.00
	Oct. 3	740	19.83	15.48	.84
	Oct. 7	907	18.38	16.94	.77
	Oct. 24	1361	18.98	15.21	.56

LINK'S HYBRID AND AMBER CROSS.

[Planted May 3. Canes uniform, good sized, not so tall as Link's Hybrid.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
172	Sept. 12	120	15.84	11.50	1.10
	Sept. 17	235	17.20	13.13	1.04
	Sept. 20	335	18.46	14.05	1.12
	Sept. 23	410	18.36	13.88	.90
	Sept. 25	469	17.85	14.26	.76
	Sept. 30	608	18.46	14.61	.74
	Oct. 2	702	19.00	14.87	.88
	Oct. 8	1006	20.55	15.69	.61
	Oct. 12	1224	18.30	14.72	.64
	Oct. 22	1312	19.42	14.80	.36

LINK'S HYBRID AND ORANGE CROSS.

[Planted May 3. Large canes, not uniform, revert to both parent types.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
159	Sept. 20	322	15.64	11.85	1.76
	Sept. 25	488	17.11	13.13	1.18
	Sept. 25	489	17.26	13.27	1.30
	Sept. 25	490	15.57	10.18	2.41
	Sept. 30	622	17.34	12.70	1.98
	Oct. 4	799	18.60	13.69	1.85
	Oct. 9	1043	18.40	14.61	.95
	Oct. 12	1217	18.34	14.43	.78
	Oct. 22	1295	18.20	13.58	1.12

LINK'S HYBRID AND RED LIBERIAN CROSS.

[Planted May 3. Uniform in type, strong and stocky canes.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
176	Sept. 12	118	14.18	9.18	2.70
	Sept. 20	343	19.56	13.47	1.02
	Sept. 23	421	19.36	11.60	.85
	Oct. 10	1136	20.19	14.71	1.26
	Oct. 22	1300	20.40	14.92	.55

VARIATION OF LINK'S HYBRID.

[Planted May 3. Short, stocky canes, very uniform in type, seem to be free from faults of Link's Hybrid. A decidedly good variation.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
171	Sept. 12	122	16.14	12.22	.94
	Sept. 20	336	18.76	14.57	.84
	Sept. 25	474	17.85	13.61	.71
	Oct. 8	1007	18.40	16.35	.62
	Oct. 12	1237	18.00	14.39	.59
	Oct. 22	1289	19.60	15.18	.46

SUMMARY OF THE ANALYSES.

In the following table will be found the maximum analysis attained by each plot, as shown by average samples taken from the entire plot. This table includes all the plots of distinct varieties which were examined.

Maximum analysis of each variety in 1889.

[Analyses of average samples of entire plot.]

[In the juice.]

Variety.	Plot.	Date.	No. of Analyses.	Total solids, Brix.	Sucrose.	Glucose.	Coeff. of purity.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Early Amber.....	01	Oct. 4	810	15.38	12.67	1.28	82.38
	049	Oct. 8	955	17.18	12.65	1.26	73.63
	050	Oct. 4	804	15.78	11.99	1.04	75.98
	235	Sept. 6	33	16.60	12.45	1.01	75.00
Folger's Early Variety.....	247	Sept. 30	594	15.24	12.74	1.53	83.59
	205	Oct. 1	677	20.24	15.71	1.65	77.61
Whiting's Early Variety....	379	Sept. 5	32	16.66	11.75	1.31	70.53
Early Tennessee	245	Sept. 6	34	10.98	8.65	3.35	78.77
Link's Hybrid	244	Oct. 7	921	19.28	16.12	.63	83.61
	10	Oct. 23	1316	17.49	14.06	.24	80.39
	116	Oct. 8	972	19.59	16.14	.61	82.39
	149	Oct. 22	1287	18.07	15.29	.50	84.61
	150	Sept. 30	605	19.27	15.76	.62	81.78
	153	Oct. 8	1001	20.94	16.05	.47	76.64
	154	Oct. 4	790	19.53	16.34	.55	83.66
	155	Oct. 22	1296	17.36	12.78	2.02	73.62
	162	Oct. 22	1294	19.98	15.68	.37	78.47
	163	Oct. 22	1303	20.58	15.83	.48	76.91
	164	Oct. 9	1031	21.34	16.52	.68	77.41
	165	Sept. 25	479	19.98	15.90	.64	79.57
	166	Oct. 22	1307	20.02	15.58	.54	77.82
Planters' Friend	177	Oct. 9	1025	16.76	11.22	2.24	66.95
	180	Oct. 7	962	14.20	10.05	1.92	70.77
	181	Oct. 24	1350	14.34	8.95	2.10	62.41
	182	Oct. 24	1358	16.44	11.37	1.75	69.16
	184	Oct. 24	1353	15.24	10.29	2.11	67.52
	185	Oct. 5	705	16.88	11.06	3.34	65.52
	186	Oct. 23	1318	20.46	16.21	.55	79.20
	188	Oct. 24	1352	16.54	10.92	1.95	66.02
	189	Oct. 24	1351	17.94	13.09	1.09	72.96
	190	Oct. 24	1359	15.94	10.76	1.93	67.50
	191	Oct. 24	1348	16.78	12.17	1.54	72.47
	376	Oct. 26	1427	20.00	14.00	2.36	70.00
Honduras	336	Oct. 25	1404	15.72	13.22	1.89	84.10
	3	Oct. 25	1380	17.07	12.93	.81	75.90
Honduras (Rose de Senegal)	103	Oct. 25	1397	16.52	12.80	1.02	77.50
Honduras	105	Oct. 12	1214	17.54	12.77	1.69	72.80
	383	Oct. 25	1413	14.38	8.06	2.91	56.05
Honduras (Texas Red).....	108	Oct. 8	975	16.74	12.67	1.13	75.85
Honduras	115	Oct. 12	1225	15.42	9.85	2.64	63.90
Honduras (Early)	119	Oct. 2	692	18.22	13.71	1.09	75.26
	120	Sept. 26	517	17.78	13.01	2.40	73.17
Red Liberian.....	27	Oct. 11	1192	20.00	14.90	1.82	74.50
	243	Oct. 7	933	17.91	10.83	3.97	60.47
	385	Oct. 14	1260	17.57	13.32	2.84	75.81
	124	Oct. 5	859	17.62	12.14	4.14	68.89
	125	Oct. 5	872	18.85	14.89	2.81	79.04
	126	Oct. 5	869	18.75	13.25	2.85	70.67
	127	Oct. 5	866	18.79	13.97	2.73	74.35
	128	Oct. 23	1328	18.34	13.83	2.18	75.41
	129	Oct. 23	1324	18.54	13.06	2.26	70.44
	130	Oct. 23	1329	17.34	12.48	2.48	71.97
	133	Oct. 23	1320	17.30	12.68	2.36	73.29
	134	Oct. 23	1337	17.84	13.28	2.78	74.44
	135	Oct. 23	1330	18.14	12.60	7.86	69.46
	136	Oct. 10	1335	17.54	12.63	1.86	72.01
	138	Oct. 23	1327	17.54	12.14	2.86	69.21
	139	Oct. 5	878	18.75	13.25	3.12	70.67
	140	Oct. 10	1221	18.89	12.43	.....	65.80
	141	Oct. 10	1116	18.78	13.69	3.40	72.89
	142	Oct. 23	1323	16.84	11.49	2.59	68.23
	145	Oct. 24	1342	15.74	10.79	3.08	68.42

Maximum analysis of each variety in 1889—Continued.

Variety.	Plot.	Date.	No. of Analyses.	Total solids, Brix.	Sucrose.	Glucose.	Coeff. of purity.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Red Liberian	374	Oct. 26	1432	22.34	14.67	2.94	65.67
	375	Oct. 26	1440	16.80	10.86	3.59	64.64
	144	Oct. 23	1331	18.14	13.62	1.78	75.08
Sorghum (Bi-color)	51	Oct. 11	1178	19.60	14.11	.76	71.99
	70	Oct. 11	1185	19.61	14.45	.61	73.69
	74	Oct. 1	653	17.30	13.47	1.01	77.86
	231	Oct. 11	1172	19.20	13.42	.76	69.89
	258	Oct. 7	903	16.20	13.77	.64	85.00
	259	Oct. 7	920	19.29	13.56	.81	70.29
	394	Oct. 5	837	18.60	13.78	.74	74.09
	395	Oct. 26	1452	15.90	10.60	1.27	66.67
	396	Oct. 26	1448	18.10	12.70	1.15	70.16
	261	Oct. 3	739	17.07	12.11	1.03	70.94
Kansas Orange	1	Oct. 8	959	19.40	15.39	.61	79.33
	2	Oct. 11	1197	18.49	14.98	.56	80.95
	15	Sept. 24	443	16.80	13.20	1.19	78.60
	240	Sept. 9	73	15.28	11.40	1.52	75.60
	390	Oct. 26	1443	17.64	13.70	.74	77.66
	200	Oct. 1	679	19.76	14.57	1.70	78.79
Early Orange	242	Oct. 3	750	16.50	12.34	2.23	74.78
	239	Oct. 7	918	19.40	14.65	2.20	75.52
	382	Oct. 5	835	20.04	14.42	2.14	71.95
	207	Sept. 23	423	18.16	14.76	3.21	81.27
Early Orange (Rio Blanco) ..	107	Oct. 5	884	20.03	17.05	1.69	85.12
New Orange (Neeazana)	193	Oct. 9	1085	19.89	14.21	2.84	71.44
	216	Oct. 7	927	19.59	14.22	2.03	72.59
	238	Oct. 3	745	19.20	14.91	1.75	77.65
	12	Oct. 8	958	20.20	14.85	1.65	73.51
Late Orange	241	Oct. 11	1173	20.80	15.71	1.92	75.53
	386	Oct. 5	832	18.21	14.76	2.18	81.06
Improved Orange	370	Oct. 3	770	20.06	14.20	3.08	70.78
	371	Oct. 5	842	16.40	12.79	2.18	77.98
	213	Sept. 30	631	19.51	14.94	2.34	76.57
	204	Oct. 26	1468	18.84	13.76	2.23	73.03
Chinese	39	Oct. 4	819	17.40	13.41	1.13	77.06
	58	Oct. 1	650	16.22	13.48	1.69	83.11
	76	Oct. 8	990	14.54	12.00	1.33	82.53
	79	Oct. 8	981	17.14	13.33	1.49	77.77
Chinese (Pootung)	80	Oct. 12	1213	16.44	13.47	1.06	81.94
Chinese	81	Oct. 8	986	17.50	13.45	1.03	76.86
	223	Oct. 3	761	15.20	10.99	2.48	72.30
	229	Oct. 27	555	16.57	11.01	1.91	66.45
Chinese (Shaw's variety)	260	Sept. 23	393	15.80	12.58	2.58	79.62
Chinese (Jyangentombi)	35	Oct. 1	651	18.20	14.63	.93	80.39
Chinese (Black Sorghum)	9	Oct. 8	957	18.20	13.32	1.55	73.19
Chinese	199	Sept. 23	420	17.54	12.22	2.75	69.67
Undendebule	254	Oct. 7	919	20.89	16.39	.81	78.46
	31	Oct. 1	662	21.22	16.77	.54	79.03
	397	Oct. 12	1210	19.14	17.12	.72	89.45
	392	Oct. 11	1164	18.60	14.07	1.42	22.28
	28	Oct. 19	1276	14.18	11.62	1.49	81.94
White India							
White India (White Mammoth)	401	Oct. 20	1398	16.00	10.95	2.11	68.44
Ubehlana	34	Oct. 8	993	19.34	14.07	1.97	72.75
	226	Oct. 3	758	16.80	12.33	2.92	73.39
	378	Oct. 10	1,114	19.68	13.49	2.64	68.54
	400	Oct. 19	1,273	15.76	11.46	.....	72.62
Texas Honey Drip	368	Oct. 26	1,423	21.30	16.35	2.42	76.76
Price's New Hybrid	251	Sept. 19	279	15.30	10.05	2.05	65.68
White African	237	Sept. 23	399	19.29	13.71	1.09	71.07
Black African	109	Oct. 5	877	19.75	15.46	.51	78.28
White Enfield	230	Oct. 24	1,355	17.10	12.51	.53	73.16
Ufataue	18	Oct. 4	823	19.15	14.38	.47	75.09
Uboyana	36	Oct. 11	1,196	17.18	12.17	1.62	70.84
Dendenunka	37	Oct. 4	821	17.42	12.67	.80	73.31
Sorghum (Blen)	101	Oct. 12	1,211	17.84	12.42	1.18	69.62
Large Goose-neck	192	Oct. 7	900	10.60	2.34	4.92	22.08
Ukubane	32	Sept. 28	578	18.66	13.89	.53	74.43
Ungatubanda	21	Oct. 1	646	15.93	12.17	.81	76.39
Chinese Imphee	14	Oct. 8	949	18.60	15.19	.37	81.67
Iowa Red Top	16	Oct. 4	820	19.97	14.67	.70	73.46

UNNAMED VARIETIES.

[Analyses of average sample of entire plot.]

[In the juice.]

Plot.	Date.	No. of analyses.	Total sol- ids, Brix.	Sucrose	Glucose	Co-effi- cient of purity.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
23	Oct. 11	1,183	18.80	13.40	1.90	71.28
257	Sept. 27	553	17.37	12.60	.81	72.54
30	Oct. 26	1,454	12.70	5.94	1.79	46.77
225	Oct. 3	753	13.60	8.64	2.08	63.53
404	Oct. 26	1,455	15.60	9.30	1.71	59.62
389	Oct. 11	1,156	17.54	11.27	2.96	64.25
227	Oct. 11	1,174	18.20	11.92	2.65	65.49
221	Oct. 7	924	17.28	12.94	1.24	74.88
224	Oct. 7	929	16.08	10.66	2.40	66.29
228	Oct. 7	936	19.81	14.06	1.90	70.97
380	Oct. 10	1,144	18.69	11.61	3.26	62.12
391	Oct. 11	1,157	16.64	10.90	1.52	65.51
248	Oct. 11	1,165	16.90	11.93	1.10	70.59
373	Oct. 26	1,434	20.56	14.37	2.70	69.89
218	Oct. 1	647	16.23	11.57	.94	71.29
234	Oct. 7	932	18.61	14.14	1.33	70.61
250	Oct. 24	1,364	17.80	14.33	.74	80.51
393	Oct. 11	1,159	19.14	14.86	1.01	77.64

From the above table the following list has been taken of ten varieties giving the best results in the three essential points of high sucrose, low glucose, and high purity.¹

List of ten varieties giving best results in 1889.

[In the juice.]

No.	Varieties.	Suc- rose-	No.	Varieties.	Glucose.	No.	Varieties.	Co-effi- cient of purity.
		<i>Per ct.</i>			<i>Per ct.</i>			
1	Undendebule	17.12	1	Link's Hybrid	.24	1	Undendebule	89.45
2	Early Orange	17.05	2	Chinese Imphee	.37	2	Early Orange	85.12
3	Link's Hybrid	16.52	3	Ufatane	.47	3	Sorghum (Bicolor) ..	85.00
4	Texas Honey Drip ..	16.35	4	Black African	.51	4	Link's Hybrid	84.61
5	Planter's Friend	16.21	5	Ukubane	.53	5	Honduras	84.10
6	Folger's Early Vari- ety.	15.71	6	White Enfield	.53	6	Folger's Early Vari- ety.	83.59
7	Late Orange	15.71	7	Undendebule	.54	7	Chinese	83.11
8	Black African	15.46	8	Planter's Friend	.55	8	Early Amber	82.38
9	Kansas Orange	15.39	9	Kansas Orange	.56	9	White India	81.94
10	Chinese Imphee	15.19	10	Sorghum (Bicolor) ..	.61	10	Chinese Imphee	81.67

From a comparison of the records made by the different varieties this year and last, the following points will be noticed:

(1) The ten varieties giving the best results in sucrose content in 1889 ranged from 17 to 15 per cent., all being above the latter figure; in 1888 the range was from 15 (circa) to 13 per cent., a difference of just about 2 per cent. between the two seasons.

(2) The ten varieties giving the lowest contents of glucose in 1889, from .25 to .60 per cent; in 1888 the range was from .50 to 1 per cent., a difference of about .40 per cent.

¹ Bull. 20, p. 126.

(3) The ten varieties giving the highest purities in 1888 ranged from 76 to 72; in 1889 from 89 to 82, a difference of over 10 points.

The superior quality of the canes this year as compared with last is principally due, as already explained, to the fact that the growing season was much better this year.

(4) The two tables giving the list of ten varieties showing best results comprise eighteen varieties each; of these, nine varieties are found in both tables, that is to say, made a good showing in at least one essential for both years. Following is the list:

List of nine varieties giving good results in at least one essential for two years.

Undendebule.	Kansas Orange.	Early Amber.
Link's Hybrid.	Sorghum Bicolor.	White Indian.
Early Orange.	Chinese.	Planter's Friend.

Of the remaining twenty-seven varieties which made a showing in but one year only, some were new this year, and some were handicapped by the late season.

(5) Link's Hybrid would seem to be entitled to the first place as an "all-around" good variety, having made a remarkable record in all three essentials for two years. Undendebule comes next, having made a record last year for low glucose and high purity, and this year obtaining a record for low glucose and heading the list in the other essentials. Red Liberian and Plot No. 14, which made such a good showing last year, do not appear amongst the first ten this year at all, although the sucrose content of both was greater this year than last; the late season was unfavorable to them.

The following table gives the maximum seed selection from each plot; it will be seen that as a rule the plot which gave the highest average analysis of its variety, gives also the highest individual cane analysis:

Maximum analysis of selected canes from each variety.

[Analyses of single stalk seed selections.]

[In the juice.]

Variety.	Plot.	Date.	No. or analyses.	Total solids, Brix.	Sucrose.	Glucose.	Co-efficient of Purity.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Early Amber	235	Sept. 7	1, 140	18. 87	14. 95	. 96	79. 22
Folger's Early Variety	205	Sept. 28	11, 567	20. 47	16. 48	. 70	80. 50
Link's Hybrid	244	Oct. 19	13, 526	21. 35	16. 72	.....	78. 31
	11	Oct. 10	13, 161	21. 83	17. 24	.....	78. 97
	116	Oct. 8	12, 815	23. 24	18. 89	.....	81. 28
	149	Oct. 4	12, 816	21. 80	17. 12	.....	78. 53
	150	Oct. 3	12, 050	22. 21	17. 94	.....	80. 77
	153	Oct. 8	12, 858	23. 43	17. 95	. 39	76. 61
	154	Oct. 8	12, 715	23. 23	18. 53	. 47	79. 76
	162	Oct. 1	11, 834	23. 49	17. 76	.....	75. 60
	163	Sept. 27	11, 517	22. 35	17. 43	. 57	77. 98
	164	Oct. 1	11, 852	23. 34	17. 91	.....	76. 73
	165	Sept. 27	11, 495	21. 89	17. 60	. 44	80. 40
	166	Oct. 2	11, 927	23. 50	18. 51	. 95	78. 76
Planter's Friend	186	Oct. 19	13, 578	22. 52	16. 75	.....	74. 37

Maximum analysis of selected canes from each variety—Continued.

Variety.	Plot.	Date.	No. of analyses.	Total solids, Brix.	Sucrose.	Glucose.	Co-efficient of Purity.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Red Liberian.....	125	Oct. 11	13, 259	21.56	15.61		72.40
	126	Oct. 11	13, 247	21.03	15.35		72.99
	127	Oct. 11	13, 298	21.91	15.61		71.24
	128	Oct. 11	13, 301	21.96	16.20		73.77
	129	Sept. 21	13, 623	19.63	14.72		74.98
	130	Oct. 21	13, 645	20.60	14.90		72.33
	134	Oct. 21	13, 632	19.76	13.76		69.63
	135	Oct. 21	13, 629	20.63	14.04		67.05
	138	Oct. 21	13, 655	20.40	13.97		68.48
	139	Oct. 21	13, 683	20.33	14.07		69.20
	140	Oct. 21	13, 698	20.63	13.99		67.81
	141	Oct. 22	13, 721	21.18	14.96		70.63
	142	Oct. 21	13, 689	20.33	14.02		68.96
Sorghum (bi-color)	51	Oct. 4	12, 299	21.71	15.44		71.11
	70	Oct. 4	12, 304	20.36	15.11		74.36
	231	Oct. 5	12, 334	20.18	14.85	.59	73.58
	258	Oct. 4	12, 281	20.61	14.69		71.27
	259	Oct. 4	12, 279	21.44	15.59	.52	72.71
	394	Oct. 12	13, 429	19.62	15.03		76.60
	396	Oct. 23	13, 873	19.48	14.93		76.83
	261	Oct. 5	12, 395	22.90	16.52		72.13
Kansas Orange	200	Oct. 2	11, 893	21.49	16.50	1.31	76.77
Early Orange	239	Oct. 7	12, 512	23.63	17.43		73.76
Early Orange (Rio-Blanco) ..	107	Oct. 7	12, 550	22.90	17.75	1.41	77.51
New Orange (Neeazana)	193	Sept. 27	11, 456	20.62	17.07		82.77
	216	Oct. 10	13, 167	21.83	15.80		72.37
	12	Sept. 26	11, 442	22.09	16.51	2.21	74.73
Late Orange	241	Oct. 5	12, 451	21.83	17.34		79.43
Improved Orange	370	Oct. 12	13, 373	22.54	15.80		70.09
	213	Sept. 28	11, 577	20.55	16.18		78.73
Chinese	39	Oct. 24	13, 947	19.15	14.00		73.10
Chinese (Jyangenbombi)	35	Oct. 25	13, 957	19.98	14.71		73.62
Undendebule	254	Oct. 2	11, 971	24.39	19.81	.71	81.22
	31	Oct. 2	12, 007	25.07	19.58		78.10
	397	Oct. 14	13, 460	20.16	16.16		80.15
	392	Oct. 23	13, 773	18.71	13.96		74.61
Ubehlana	34	Oct. 25	13, 961	19.98	14.81		74.12
	226	Oct. 26	14, 150	18.42	12.96		70.35
White African	237	Sept. 26	11, 448	19.76	13.73		69.49
Black African	109	Sept. 20	11, 237	21.90	16.70	.67	76.25
Ufatane	18	Oct. 12	13, 379	21.30	16.07		75.44
Chinese Imphee	14	Sept. 25	11, 369	22.41	17.15	.43	76.52
Iowa Red-top	16	Sept. 26	11, 434	20.29	15.86	.64	78.16

Maximum analysis of unnamed varieties.

[Analyses of single stalk seed selections.]

UNNAMED VARIETIES.

[In the juice.]

Plot.	Date.	No. of analyses.	Total solids, Brix.	Sucrose.	Glucose.	Co-efficient of Purity.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
228	Oct. 26	14, 154	19.32	16.09		83.28
373	Oct. 12	13, 348	23.71	18.03	1.42	76.04
218	Oct. 7	12, 516	20.43	13.60	.77	66.56
250	Oct. 7	12, 611	22.69	16.99	.91	74.87
393	Oct. 23	13, 779	19.02	15.98		84.01

From the above table the following list has been prepared, giving the ten varieties showing the highest results in sucrose from analyses of single selected stalks. It will be seen that nearly the same varieties are comprised in it as those contained in the table giving the ten best varieties of sucrose content from analyses of average samples, and the order is also about the same.

List of ten varieties giving best results based on analyses of single selected stalks (1889).

[In the juice.]

Variety.	Sucrose.	Variety.	Sucrose.
	<i>Per cent.</i>		<i>Per cent.</i>
1. Undendebule	19.81	6. Chinese Imphee	17.15
2. Link's Hybrid	18.89	7. New Orange	17.07
3. Plot 373	18.03	8. Plot 250	16.99
4. Early Orange	17.75	9. Planter's Friend	16.75
5. Late Orange	17.34	10. Black African	16.70

Following is a list of the five plots of crosses giving the highest sucrose content for the season:

[In the juice.]

Plot.	Variety.	Sucrose.
		<i>Per cent.</i>
293	Amber and Orange Cross	16.94
318	White India and Orange Cross	16.70
111	Variation of Honduras	16.51
171	Variation of Link's Hybrid	16.35
313	.....	15.85

GENERAL CONCLUSIONS.

In summing up the results of two seasons of experimental work in improving sorghum, it may be said that where crossing of varieties and subvarieties has been excluded, it appears to inherit the qualities and even the peculiarities of the parent as closely as other plants.

Some of the new varieties have shown a high percentage of sugar for two seasons.

Some of the new varieties tested have shown for two seasons a much lower percentage of uncrystallizable sugar than the ordinary varieties.

Some of the varieties have retained a high percentage of sugar for from thirty to forty-eight days.

It appears that much of the extreme variableness which has been attributed to the sorghum plant is caused by differences in time of maturing in the canes, and it appears that these differences may be diminished by "family breeding," that is, separate planting of selected seed, and also by such methods of planting and of cultivation as will cause all the canes to mature before any deteriorate.

It appears that valuable new varieties may be produced by crossing two good varieties, and that new varieties having distinct and uniform characters can be produced by selecting variations from ordinary types.

It appears that early maturing subvarieties may be produced from varieties which mature too late by selecting seed from the first maturing canes of those varieties.

While the results obtained by a first selection in one season can not be regarded as conclusive, yet it appears that improved varieties of sorghum which will yield more sugar than the best of the present varieties may be created by continued selection of seed from the canes which yield most sugar.

INDEX.

A.

	Page.
Agricultural conditions, studies of.....	47
Aid to the sorghum sugar industry, character of.....	50
Alvord, Mr. H. E., report of	52-55
American Sugar Company, alleged fraudulent practices of.....	35
Appropriations for scientific agriculture, date of	51
Area of sorghum sugar growing	20
Arid regions, factories in.....	47
Arkalon Sugar Works.....	10
Attica, character of factory at	26
culture experiments at.....	29
manufacturing experiments at.....	26
multiple effect pan at.....	26
sugar works, description of.....	9

B.

Baton Rouge, culture experiments at	23
Bozarth, Mr. John, report of.....	57

C.

Cane, loss of on manufacture	27
percentage of leaves and tops in.....	27
Carr, Mr. Oma, report of	72-77
Cedar Falls, experiments at	12
prospects of success at	13
Chemical force, disposition of	7
Chip, effect of size of.....	17
College Station, culture experiments at.....	51
diagram of sorghum field at, facing page	51
fertilizers used at, analyses of.....	52
Conway Springs, character of cane crop at	24
culture experiments at	25
double factory at	24
experimental run at	25
imperfections of factory at	24
lack of water at.....	24
manufacturing experiments at.....	23
water-works of	24
Cook, Mr. W. W., appointment of, as agent.....	6
instructions of.....	32
report of, on American Sugar Company.....	35

	Page.
Cook, Mr. W. W., report of, on Attica factory	38
Conway Springs factory	37
Fort Scott factory	36
Medicine Lodge factory	39-41
Ness City factory	33
Southwestern Sugar Company	34
Crampton, Mr. C. A., and A. A. Denton, report of	82
Cultivation, improvements by	91
Culture experiments, summary of	49

D.

Denton, Mr. A. A., and C. A. Crampton, report of	82
Deterioration of sorghum	92
Diffusion, in open cells, disadvantages of	16
instantaneous	18
juice, filtering of	27

E.

Exhausted chips, burning of	45
Experiments, classes of	5

F.

Factory, consideration of location of	42
cost of	45, 46
technical and chemical control of	46
Fertilizers, application of	51
influence of, on sugar content	55-57
Fuelling, Mr. John L., report of	79-81
Fuel, supply of	44
Fund, amount of, for sugar experiments	5

H.

Horton, Mr. H. E. L., report of	58-62
Hughes system of diffusion, possibilities of	17

I.

Inversion in the battery	28
of sugar in sorghum cane	21

J.

Jennings process, report on	58
Juice, effects of rain on	94
preservation of, by lead subacetate	93

K.

Kenner, character of work at	21
culture experiments at	22
manufacturing experiments at	21
size of battery at	21
Knorr, Mr. A. E., report of	58

L.

Large seed heads, indication of	94
Liberal Sugar Works, description of	10
Link's hybrid, value of for making sugar	23
Losses in manufacture, location of	28

	Page.
M.	
Manufacturing work, summary of	42
Maximum content of sugar, length of time retained	95
Maxwell, Mr. W., report of	63
McElroy, Mr. K. P., report of	81, 82
Meade Sugar Works, description of	10
Medicine Lodge, amount of sugar made per ton of cane at	31
cane not worked at	30
culture experiments at	31
delays, due to new machinery at	30
manufacturing operations at	30
mean composition of the cane juices at	31
sugar-works, description of	9
Methods of improving sorghum	82
principles of	83
Morrisville, culture experiments at	20
manufacturing work at	20
Multiple effect pan, advantages of double system of	30
heating surface of, for sorghum	26
N.	
Nesbit, Mr. D. M., report of	56
Nitrogen, effect of, on vegetation	19
Normal diffusion, description of	18
theory of	17
P.	
Plots from single seed head	90
Prefatory note	3
Proximity of cane fields, importance of	44
Public aid to sorghum sugar, conditions of	49
R.	
Rain fall, amount of, in Washington	55
Report of June 1, 1889, abstract of	6
Reports from assistants, nature of	12
Rio Grande, culture experiments at	19
discussion of results at	14
machinery used at	15
results of three years' experimental work at	15
sugar made at	15
S.	
Sauborn, Mr. T. F., report of	77, 78
Schweinitz, Mr. E. A. von, report of	65-72
Seed selection, method of	14
Seed, selection of	87
progress made in	88
Selected canes, maximum analyses of	106, 107
Soil and climate, importance of	42
Sorghum cane, conditions of growth of	50
growth of, in sugar-cane countries	22
sugar culture, limits of	47
industry, erroneous impressions of	49
financial disasters of	49
public aid to	48

	Page.
Southern Kansas Sugar Works, description of.....	7, 8
Spencer, Mr. G. L., report of	7
Sterling, analyses of crosses and variations at.....	101, 102
description of work done at.....	96
general conclusions from work at	108
result of analyses at	97-100
Stubbs, Mr. W. C., report of	64, 65
Sugar, manufacture of, on a small scale	16
school, establishment of.....	7
T.	
Tour of inspection, description of.....	11
general impressions of.....	12
U.	
Uniform time of ripening cane.....	89
V.	
Variations, preservation of	85
Varieties of cane, accidental crossing of.....	86
best analyses of, from single stalks	108
exclusion of inferior	84
experiments in growing.....	83
giving best results	105, 106
hybridizing of	85
seasons of 1888 and 1889, contrast of	84
W.	
Water supply, disasters of insufficient.....	48
importance of	43
Wet season, effect of, on cane	57
Work, character, and allotment of	5

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 27.

THE SUGAR-BEET INDUSTRY.

CULTURE OF THE SUGAR-BEET

AND

MANUFACTURE OF BEET SUGAR.

H. W. LEY,

CHEMIST

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1890.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 27.

THE SUGAR-BEET INDUSTRY.

EXPERIMENT STATION.
JUN 1890
UNIVERSITY OF ILLINOIS

CULTURE OF THE SUGAR-BEET

AND

MANUFACTURE OF BEET SUGAR.

BY

H. W. WILEY,

CHEMIST.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

Compliments of
J M Rusk
Secretary of Agriculture.

PREFATORY NOTE.

WASHINGTON, D. C., May 12, 1890.

SIR: I have the honor to submit herewith, for your inspection and approval, the manuscript of Bulletin No. 27 of the chemical division, entitled "The Sugar-Beet Industry."

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary.

INTRODUCTION.

During the past year the Department of Agriculture has received many hundreds of inquiries from all parts of the United States relating to the culture of the sugar-beet and the production of sugar therefrom. This growing interest in beet culture, together with the fact that all the

DESCRIPTION OF PLATES.

Plate 1.—Mature sugar beet, see page 159.

Plate 2.—Map showing belt suitable to beet culture—opposite page 169 (marked Plate 1 by mistake of printer).

Plate 3.—Steffen's process—plan of first floor, page 250.

Plate 4.—Steffen's process—plan of second floor, page 250.

Plate 5.—Steffen's process—side view, page 250.

Plate 6.—Steffen's process—end view, page 250.

Plates 7, 8, and 9 (marked by mistake of printer 6, 7, and 8).—Plans for sugar-house, pages 253, 254, 255.

Plates 10 and 11.—General arrangement of machinery in a beet sugar factory, page 254.

the United States, and this matter will also be incorporated in this bul-

A. D. 2239

INTRODUCTION.

During the past year the Department of Agriculture has received many hundreds of inquiries from all parts of the United States relating to the culture of the sugar-beet and the production of sugar therefrom. This growing interest in beet culture, together with the fact that all the previous publications of the Department concerning the sugar-beet are out of print, has led to the preparation of the present bulletin.

The object of this bulletin is to give, as nearly as possible, the present condition of the beet sugar industry of the United States; to locate, approximately, those portions of the country which are best suited for the production of the sugar-beet, and to indicate the line of work necessary to the successful introduction and extension of the beet sugar industry in this country.

In connection with the elaboration of the above plan, a résumé will be given of the publications of the Department on this subject, above referred to, and which are no longer accessible to the public. The principal publications, omitting the brief accounts published in Annual Reports which have been issued by the Department, are as follows:

(1) "Report on the Culture of the Sugar-beet and the Manufacture of Sugar therefrom in France and the United States," by Dr. Wm. McMurtrie; Government Printing Office, 1880, pages 294.

(2) "The Beet Sugar Industry of the United States," Bulletin No. 3, of the Chemical Division, pages 24 to 27 with 12 mean temperature charts.

(3) Bulletin No. 5 of the Chemical Division, Part Second, "Beet Sugar," pages 37 to 137, inclusive, with 12 plates.

In addition to the above publications, numerous articles, mostly abstracts of the above, have appeared in the Annual Reports, and a few pages of the bulletin entitled "Encouragement to the Sorghum and Beet Sugar Industry," issued in 1883 by the Department, were devoted to the sugar-beet.

It is evident that a work of this kind for the United States must be chiefly a compilation of the results obtained in other countries, since the industry here is so young that little is known of it from our own investigations. Nevertheless, a large quantity of material has been gathered during the past year relating to beet sugar in various parts of the United States, and this matter will also be incorporated in this bul-

A. D. 2239

letin. It must be understood that the object of this bulletin is not to give a complete treatise upon the culture of the sugar-beet and the manufacture of sugar therefrom, but simply to indicate in a general way, for the information of those interested, the general principles of this industry. One especial object which will be kept in view will be to prevent those intending to engage in this industry from going wrong in the beginning, and squandering their money and time in battling with problems which science has already met and overcome. It is further hoped that the careful perusal of the data which will be presented will prevent any mistakes from being made which would end in financial disaster and which are so apt to attend the early history of every industry.

There will probably be found for many years to come in the United States more enthusiasm than knowledge connected with the sugar-beet, and the result of this will be, unless great care be taken, that many ventures will be made which may result in financial disaster, disaster which could have been avoided by a thorough comprehension of the fundamental principles of the industry.

In so far as the manufacture of sugar from the matured beet is concerned we are able to start at the present time with the accumulated knowledge and experience of three-quarters of a century of investigation. So perfect have the processes of manufacture become that nearly all of the sugar which is stored in the beet can be secured in merchantable form and by comparatively inexpensive methods. By the term inexpensive, however, it must be understood that the actual processes of manufacture are denoted and not the cost of the machinery. The various processes for the extraction of the sugar from the beet, the best methods of clarifying the juice and of evaporating it and for separating the sugar from the molasses, are thoroughly well understood and are no longer legitimate subjects for public experiment. The great problem in this country is the agricultural one. The selection of suitable soil, the finding of the proper climatic conditions, and instruction in the method of planting, cultivating, and harvesting the beets, are all matters of vital importance. Without a careful study of these subjects, and without the proper knowledge thereof, it will be a hopeless task to introduce successfully the beet sugar industry into this country.

One of the great dangers to be avoided is the formation of hasty conclusions in regard to the proper localities for the production of the sugar-beet. Often without any study whatever of the climatic conditions or of the character of the soil, efforts are made to build large and expensive factories, which as often have to be abandoned on account of having been wrongly located. The studies which have been made heretofore in regard to climatic conditions have been of such a nature as to locate, in a general way, the areas in the United States suitable for the culture of the sugar-beet.

It has been found in general that the coast valleys of California,

and probably large areas near the coast in Oregon and Washington, certain parts of the Dakotas and Nebraska, localities in Minnesota, Iowa, Wisconsin, and Michigan, parts of northern Illinois, Indiana, Ohio, and New York present favorable conditions for sugar-beet culture, but in the localities thus broadly intimated there are certain restricted areas most suitable to the sugar-beet, and it is only these restricted areas to which we must look for success. The fact that in one locality, for instance in Nebraska, good sugar-beets can be produced would be no warrant whatever for assuming that all parts of that State were equally suitable for this purpose, and this remark may be applied to every one of the States mentioned above.

Sugar-beets have also been raised in other localities in the United States, notably in New England, New Jersey, Delaware, and Kansas, and while there may be areas in the New England States where beets can be successfully grown, it must be admitted that the States last named stand in the second rank of beet sugar producing localities. In Kansas, during the last year, as will be shown in the body of this report, sugar-beets were grown and a considerable quantity of sugar manufactured therefrom. This, however, does not show that Kansas will be able to compete with more favorable localities in the production of beet sugar.

In general it may be said that the summers in Kansas are too hot to expect the production of a sugar-beet uniform in its nature and containing a high percentage of sugar.

If the sugar-beet industry is to succeed in this country this success must come from sharp competition with the same industry in older countries, where its conditions are better understood and where the localities suited to it have been selected by long and often costly experience. It must also compete with the sugar-cane industry, both of this country and of tropical countries, and for this reason we can only expect it to survive in those localities where soil and climatic conditions, proximity of fuel, cheapness of labor, and other favorable environments are found.

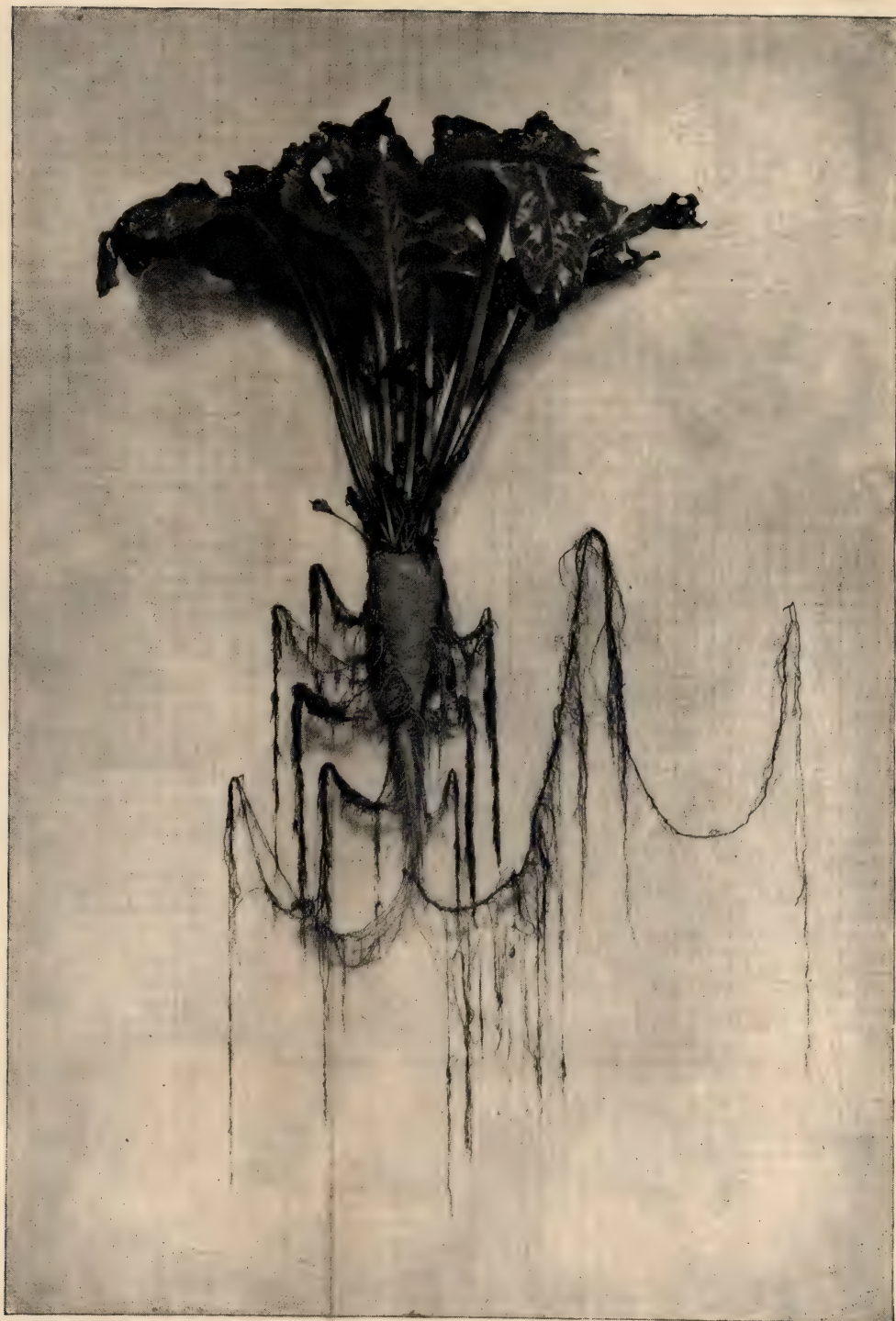
It is to be hoped that the mistakes which have so long threatened the sorghum sugar industry with destruction may be avoided with the sugar-beet. Calm judgment and sober reason must not give way to enthusiasm and extravagant expectations. All conditions of success must be carefully studied, all the difficulties in the way of success must be intimately investigated and allowed for, and ample capital, coupled with judicious perseverance, must be enlisted in its behalf.

Many attempts have been made for the past twenty-five years to introduce the beet-sugar industry into the United States. Factories have been located in the New England States, notably in Maine and Massachusetts, also in Delaware, in Illinois, and in California. With two exceptions all of these ventures have brought with them financial disaster. The factories in New England, Delaware, and Illinois, and some of those

started in California have been abandoned. One factory in California has been very successfully operated for a number of years, viz, the one at Alvarado. Another one, viz, at Watsonville, has been in successful operation for two years. From the success of these two it is reasonable to infer that others must also succeed when the proper conditions are supplied. It is well, however, that just now, when there seems to be such an awakening in regard to beet sugar, a few words of warning should be spoken. Any further financial disasters would exercise a most depressing effect upon the advancement of the industry. These disasters are sure to come if attempts are made to erect factories in a short time in localities where the capabilities of the soil and climate are untried, with capital insufficient in amount, and under the direction of those unskilled in all the branches of the industry itself.

For the proper erection and completion of a beet sugar factory not less than twelve months should be allowed, and even in this time it can only be properly accomplished under experienced technical control. During the present month, March, 1890, letters have been received at this Department from persons who contemplate the erection of a factory during the present season to be ready for operation by October 1. The orders for the machinery for these factories have not even yet been placed nor the contracts for the building let nor arrangements made for growing the beets.

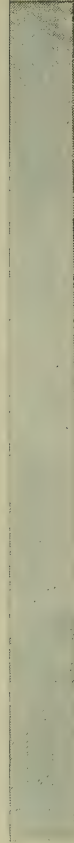
It is easy to see that if such a work as this is pushed forward it can only end in failure. In contrast with this I may cite the instance of another factory, which is now in course of erection, which was located after a whole year spent in studying the conditions of soil and climate and in the actual growth of numerous plots of beets, and for which the machinery was ordered fully a year in advance of the time when it was to be used. The success of such a factory is almost a foregone conclusion. It is to be hoped that all persons intending to invest in the beet sugar industry may follow the latter and not the former example.



THE MATURE SUGAR-BEET.

Scale, $\frac{1}{2}$.

TE 1.



THE SUGAR-BEET INDUSTRY.

HISTORICAL.

THE EARLY HISTORY OF THE SUGAR-BEET AND THE MANUFACTURE OF SUGAR THEREFROM.*

"It is difficult to trace the exact origin of this plant, which has become of so much interest and value in Europe, and is not only of national but also of continental importance to the people of the other side of the Atlantic. Its antiquity finds evidence in the fact that Theophrastus described two varieties: the deep-red, and the white beet. Olivier de Serres, in his writings in 1590, makes mention only of the red beet, and states that it had not long been introduced into Europe, and says that "the juice yielded on boiling is similar to sugar sirup." This variety was introduced in England in 1548, but the white variety was not known until 1570.

"According to the Abbé Rosier, four varieties were already known in 1782, the small and large red, the yellow, and the white. The variety known as *disette*, and which is still grown in France for feeding purposes, was believed to have originated in Germany. It was brought into notice by Vilmorin, the ancestor of the present head of the great seed house of Vilmorin-Andrieux & Co., who died in 1804, and was introduced by Perkins into England in 1786.

"The root does not seem to have been considered as having an industrial value, and was cultivated only for the table or for cattle food until 1747, when Margraff, a member of the Berlin Academy of Sciences, believing sugar to be a regular constituent of plants other than the sugar-cane, made examination of different varieties of vegetables, and succeeded in separating from several kinds varying quantities of crystallizable sugar. His method of research consisted in cutting the material to be examined into thin slices, rapidly drying it, reducing to fine powder, and exhausting with diluted alcohol. The results of his researches were announced in a memoir read before the Berlin Academy of Sciences, in the year above mentioned. Of all the plants examined, he found the beet to be the richest in sugar, and believing that Europe would find in this root the basis of an immense industry, he urged the importance of his discovery upon the Academy, hoping to see valuable

* Culture of the Sugar-Beet. U. S. Department of Agriculture. Special report No. 28. By Dr. William McMurtrie. 1880.

and practical results follow it; but he was not destined to see his hopes fulfilled. His methods of work, which were at best imperfect, were of a nature to succeed only in the laboratory, and the prices of colonial sugars were so low as to render competition by the products from a new and untried source out of the question.

"This important discovery, therefore, remained dormant for nearly half a century, when one of Margraff's pupils, Karl Franz Achard, son of a French refugee in Prussia after the revocation of the celebrated edict of Nantes, and director of the Academy of Sciences of Berlin, again took up the line of research started by his preceptor, and finally succeeded in extracting sugar from the root on a comparatively large scale. The process he employed was peculiarly his own, and gave results which were at the time of an astonishing character. He announced his results in 1797, published his mode of operation, and in the latter part of 1799 presented a sample of his product, with a description of his method, to the Institute of France, stating that the cost of production of muscovado of good quality should not exceed 6 cents per pound. Achard's statements were as much the subject of doubt and even of severe ridicule by the people of his time as are the statements made by the Department of Agriculture in relation to sugar produced at the present time from sorghum and maize, and were even accepted with reserve by the members of the Institute of France, notwithstanding the high repute he enjoyed among his scientific *confrères*. The interest of the French Institute was so aroused, however, that a commission was appointed by that body to make an examination of the work of Achard and to repeat his experiments. The commission consisted of Cels, Chaptal, Darcet, Fourcroy, Guyton, Parmentier, Tessier, Vauquelin, and Deyeux. In their report they stated that Bermond had made unsuccessful experiments in the introduction of the culture of the sugar-cane in France, and the same was the result with the sugar-maple, for though the latter might possibly be grown it could never compete with the sugar-cane. Other plants had been experimented with; the turnip, carrot, parsnip, chestnut, stalks of maize, and many other plants were submitted to experiment, but, notwithstanding the assertions of certain enthusiasts, it was proven that none of these plants could supplant the cane, and that in spite of the sugar they were presumed to contain the experiments were unsuccessful. Such was the state of things when Achard made the announcement of his experiments and results.

"The commission then proceeded to state that they had repeated the experiments of Margaff to determine the value of their roots, finding them to contain a little over 6 per cent. of sugar. They applied the method of Achard for extraction on a larger scale, repeated several times, and succeeded in obtaining only a muscovado of very brown color and disagreeable to the taste. This muscovado, however, was readily purified by means of alcohol, and in this way a sugar candy was obtained differing in no particular from that given by cane sugar.

"The conclusions arrived at were to the effect that if with Achard's process sugar may be extracted from the beet, the quantity was much less than that given by the alcohol process indicated by Margraff.

"They then modified the experiments by working on the juice of uncooked beets and obtained 25 per cent. more of muscovado; and as a final result of all their experiments they adopt as the cost of refined sugar about 18 cents per pound, but think this figure may be reduced by improved methods.

The report concludes as follows :

It results from what precedes :

(1) That it is certain that the beet which grows in France, and which may be recognized by its white flesh, traversed by red bands or rays, contains sugar as well as the same species grown at Berlin that Achard worked upon.

(2) That the sugar may be extracted by various processes, and acquire by aid of repeated purifications all the qualities of cane sugar.

(3) That the quantity of sugar which this root contains is so great that attention should be given to its extraction.

(4) If, as we are assured by Achard, we may, as it were, render this root richer in sugar at will by caring for its culture, it is desirable that experiments be made upon this subject.

(5) That independently of these experiments it would be of value to determine if, among the several varieties, some do not exist more rich in sugar than those pointed out by Achard.

(6) That, admitting the results of these experiments, it remains to be demonstrated that the beet may up to a certain point supplant the sugar-cane.

(7) That it is true to say that the cost of sugar can not be determined with rigorous exactness without knowing the results of operations made on a large scale. However, at the present time it may be presumed that this price would not be higher than that of cane sugar in ordinary times.

(8) Finally, if Margraff should justly be cited as being the author of the discovery of sugar in the beet, it must also be admitted that Achard is the first to have made fortunate application of this discovery, not only in announcing the favorable quantity that may be extracted, but also in pointing out the processes to which we could resort for success.

"Achard's appreciation of the action and conclusions of this commission may be gleaned from the following letter addressed to Citizen von Mons, and dated Berlin, November 16, 1800 (*Ann. de Chem.* 39, 223):

I thank you sincerely for sending me the interesting report of the Institute. I have noted with infinite pleasure that the researches made by the celebrated French chemists confirm my discovery. The differences found in the products as to the quantities and qualities result either from the culture of the beet or the variety chosen for the tests. Notwithstanding the objections of the commission, I am still of the opinion that the best method consists in boiling the roots before expressing the juice, the clarification then taking place within the cells themselves by the coagulation of the albumen, so that we obtain the juice entirely clarified, or better clarified than it is possible to attain from raw beets by the addition of blood or other coagulable substances.

"But the report of the French commission had the effect to dampen any enthusiasm that may have been aroused in France by the publication of Achard's announcement, and for the few years that immediately

followed it no interest seems to have been manifested there on the subject.

“It was, however, otherwise in Germany. Achard’s letter proves that his zeal was in no way abated, and other workers were eagerly following the new line of investigation and experiment now made so attractive by Achard; and Lampadius, professor of chemistry and metallurgy at the School of Mines at Freyburg, took it up, repeated the experiments of his eminent predecessor in the work, improved upon his methods, from the average results of which he estimated the cost of refined sugar would not exceed 18 cents per English pound, about the same limit established by the commission of the Institute. Hermbstaedt also, modifying the method of Achard, succeeded in extracting from 125 pounds of roots of *Beta vulgaris* $5\frac{1}{2}$ pounds of brown sugar and $1\frac{7}{8}$ pounds of sirup, which drained off. The Baron de Koppy, having interest and confidence in the methods and results of Achard, erected in 1805 upon his estate at Krayn, near the town of Strehlen, in Lower Silesia, works capable of the annual extraction of the sugar contained in about 525 tons of roots, besides the manufacture of the rum and vinegar resulting from the utilization of the wastes of manufacture, viz, the pulp and molasses. These works of Koppy were constructed after the designs furnished by Achard, and carried on according to the methods he had determined. Achard also erected a factory on his own estate at Cunern, near Steinau, on the Oder. The results obtained by these two enterprising pioneers in the beet-sugar industry were followed by the establishment of other works at Athaldsleben and near Augsburg, and the interest which had thus been aroused in Germany bid fair to be again communicated to the French. This was hastened by a letter of Achard to the editor of the *Moniteur*, and published in that journal of October 2, 1808. This so thoroughly explains his position, the character of his work, and the progress he had made since the report upon his former results, that we deem it of value to reproduce it here:

SIR: The manufacture of sugar in Europe being, in all its relations, and principally under existing circumstances, a very important object, I believe that you will not refuse to give publicity, in the *Moniteur*, to an exposé of the results of my researches upon the manufacture of sugar from the beet root, and the advantages which this new kind of European industry assures to all nations for which sugar is an exotic staple.

It was decided by the report given by the celebrated chemists, Cels, Chaptal, Fourcroy, Guyton, Parmentier, Tessier, Vauquelin, and Deyeux, under date of January 25, 1800, to the class of mathematical and physical sciences of the National Institute of France, upon the examination they made of my researches tending to the profitable extraction of sugar from beets—

A. That the beet contains sugar.

B. That the sugar may be extracted by different processes, and acquire by sufficient purification all the properties of cane sugar.

C. That even by following my first methods, which were still very imperfect at the time the celebrated French chemists were occupied with their varification, it was to be presumed that the price of beet-root sugar would not be higher than that of the cane in ordinary times.

D. That all doubts of the existence of sugar in the beet root and the possibility of extracting it being dissipated, it only remains to be desired that the experiments made on a larger scale may give to my work upon this object the degree of authenticity it merits.

Encouraged by the suffrage of so illustrious savants, I have labored during eight years to perfect the manufacture of sugar from beets by experimental researches made on a large scale in a factory I have established on an estate called Cunern, which I own near Steinau, in Lower Silesia. My labors have led to the determination of a much more profitable method for extracting the sugar from beet roots, so that by my new processes 25,000 kilograms (55,000 pounds) of these roots furnished 2,309 French pounds (2,098 English pounds) of unclayed muscovado, richer in pure crystalline sugar, in the relation of 662 to 591 than the brown muscovado of Jamaica, or 1,923 French pounds (1,748 English pounds) of a clayed muscovado richer in pure sugar in the relation of 666 to 664 than the white muscovado of Martinique, while by following my first imperfect methods the commission appointed by the Institute of France to repeat my experiments extracted and was able to extract from 25,000 kilograms (55,000 pounds) of roots, the product of 1 arpent of land (about 1 acre), only 782 pounds of muscovado (711 English pounds), containing 448 French pounds (407 English pounds) of pure sugar; that is, about one-third the quantity that may be extracted by aid of my new processes. The cost of production of muscovado from beet root according to my new processes, provided the extraction is carried on in a well-established factory, and the manufacturer secures his roots at the moderate price by growing them himself, as those in the colonies almost exclusively cultivate the cane, is compensated for as much by the leaves of the beets, which serve as food for cattle, as by the rum, other spirits, and vinegar extracted from the wastes of manufacturing the muscovado; that is, the pulp of the root exhausted of the juice which the press can remove, and the molasses.

The same being the case with the cane, it follows that sugar may be extracted with the same pecuniary advantage from the beet in Europe as from the cane in the islands. An arpent yielding, according to the basis determined by the French commission charged with repeating my first experiments, 25,000 kilograms of beets, from which is extracted by my perfected methods 2,309 and 1,923 pounds of muscovado, according to the quality given it, it follows that to produce 10,000,000 pounds of muscovado, it is necessary to set apart during the summer months only between 4,330 and 5,200 arpents of land to the culture of the beet. An area of this extent is too small to cause its use in the production of indigenous sugar to be followed by the restriction of other important cultures, and this is all the more true since it is necessary to set apart for the culture of the beet, as it is practiced in this province, only fields which have been used two years for the culture of spring and winter wheats and remain a third year in fallow without furnishing other products than the pasturage of cattle that are allowed to range upon it, and which is more than compensated for by the leaves of beets. The facts I have established in the preceding article are based—

A. Upon the report which the commission appointed to repeat my first essays in the extraction of sugar from the beet made in 1800 to the class of mathematical and physical sciences of the Institute of Sciences of France.

B. Upon the later official examinations of my manufacture of sugar at Cunern by my newly perfected methods and the results they have given, made by a commission appointed by the Prussian Government.

C. Upon the results furnished by a beet-root sugar factory established in this province according to my instructions by M. le Baron de Koppy on his place called Krayn, near the town of Strehlen. This establishment is adapted to the annual extraction of the sugar contained in 10,000 Silesian quintals or 577,500* kilograms of beets, besides the manufacture of the rum and vinegar which is obtained from the wastes of preparing muscovado, viz, the pulp of pressed beets and molasses.

* 537 tons of 2,200 pounds.

The constant success with which the manufacture of muscovado established at Krayn has worked during three years, and the profit it assures its possessor, confirm the results presented by the official examinations which have been made of the manufacture of muscovado according to my perfected methods, so that it is perfectly proven :

(1) That the muscovado furnished by the beet root is of a quality equal to that of the cane.

(2) That the quantity of muscovado furnished by beet roots is found so thoroughly proportional to the cost of its extraction and the profits obtained from the waste products of manufacture in employing them for that of rum or other spirits of the better quality, and a very good vinegar, that these advantages under favorable local circumstances wholly, and under all circumstances in a great part, compensate for the cost of production of muscovado from beets, as is also the case with regard to the muscovado from the cane—the cost of extraction of which is more or less compensated for by the rum extracted from the waste products they leave.

(3) That the manufacture of sugar from beet roots may become the object of an important industry for Europe.

(a) By the very considerable sums it will save from exportation.

(b) By the means it will furnish a large number of persons of the indigent classes to procure subsistence in the manual labor it requires.

(c) By the independence in which, with regard to this staple, it places Europe and other parts of the world which are really the principal depositories.

(Signed)

ACHARD.

CUNERN, near STEINAU, LOWER SILESIA, 1808.

“The following article, from the *Moniteur* of March 2, 1811, will also be of interest in this connection, as corroborating the statements of Achard :

His excellency the minister of the interior, in making his report to His Majesty upon the sugar of beet roots, had hoped to be able to assure him that, according to the testimony of M. Deyeux, this sugar would present the double advantage of enriching those who entered into the manufacture and cost a price low enough for consumers.

But if M. Deyeux was unable to give this assurance on account of the fact that the main end of his work was in the interest of French speculators, to effect an improvement upon the processes of the German chemists, we may find it in the success already obtained in the establishment of the Baron de Koppy, success thoroughly recognized in Germany, and of which we have an eye-witness in M. Boudet, chief pharmacist to the army.

It will be remembered that M. Achard, chemist in Berlin, who first conceived the idea of making the extraction of sugar from beet roots an object of speculation and manufacture, announced in the *Moniteur* of 1802 the advantages of this sugar, which he procured by a process more perfect than that which four years before had not been unreservedly accepted by the Institute of France.

This number of the *Moniteur* having reached Breslau, capital of Silesia, and consequently in the neighborhood of the two factories said to exist in the province of Prussia, M. Boudet, being there at the time, considered it of value to verify the facts advanced by Achard, in order in case of need to be able to destroy or increase the impression which the article in the *Moniteur* may have produced in France. He accordingly betook himself to the house of Baron de Koppy, at Krain,* near the town of Strelzlen,* and visited the manufactory. He caused to be sent to M. Parmentier a memoir, an extract of which was inserted in the *Bulletin de Pharmacie* of the month of February, 1809.

* In other places these are written Krayn and Strehlen.

We shall not dwell upon the interesting details into which M. Boudet entered to elucidate for his countrymen the means of establishing similar manufactories in Europe. It is sufficient for our purpose here to make known the profit obtained by Baron de Koppy from his own works at the time of the visit of M. Boudet.

He affirms (1) that Baron de Koppy is very well satisfied with the quantity of sugar, rum, spirits, and vinegar furnished by his beets, and with the ready and lucrative sale he had for these different staples; (2) that the culture of beet roots, far from diminishing that of wheat, contributed to procure for him more abundant crops than be obtained before, first, because in employing for beets only the lands formerly left to fallow, his wheat occupied the same area as before he thought of making sugar; and, second, because beets furnish, besides their sugar, a large mass of food for cattle and sheep. He was able, without enlarging his domain, to double the number of his cattle, to obtain more manure, and with the aid of this manure to obtain larger quantities of wheat. (3) He admitted that he owed to the existing war a large portion of the profits given him by a sugar the people were obliged to use in default of that from canes, but he asserted that should he in times of peace obtain from his factory only the cost of cultivation of the beets and the manipulation of the sugar, he would guard himself from abandoning it so as not to renounce the prosperity it had given him and which it could always preserve on his domain.

The sugar sold by Baron de Koppy was not refined. M. Boudet wished to know for himself if it was susceptible of being. The trial he made having succeeded, he thought this sugar would become that of the richer classes, at least until we have the sugar from grapes M. Proust had led us to hope for, the sirup of grapes having already replaced for the poor that of the cane.

The establishment of beet-sugar factories may therefore be undertaken with confidence throughout the empire; but we must observe, according to the memoir of M. Boudet, it is especially to the large proprietors that it will be profitable, and that they should content themselves with making raw sugar to be sent like that of the islands to the refineries, one of which is able to purify and convert into loaves the products of twenty factories.

“As Baron de Koppy admits in his statements to M. Boudet, the events which were brought about by the political conditions of the time did much to favor the success of the enterprise, for shortly after his works were started—in fact, in the years immediately following—Napoleon I issued his famous decrees of Berlin and Milan, establishing the famous continental blockade, and excluding from the markets and consumption all material whatsoever of English production or manufacture, and particularly the products of England’s colonies. This, of course, made sugars scarce and dear, and enhanced the profits of the manufacture that Achard and Koppy had so opportunely developed.

“The same conditions stimulated the search for products indigenous to France that might be substituted for those colonial staples which had become articles of daily consumption, and the deprivation of which was most keenly felt, and sugar seemed to have claimed instant attention. But the source developed by Achard seems to have almost completely vanished from the thoughts of both scientists and practical manufacturers. The destruction of external commerce, of course, resulted in the downfall of the wine trade, and all eyes and all minds naturally turn to the utilization of the enormous crops of grapes France annually produced, and everybody seemed to look to the sugar this fruit contained, both as a substitute for the wanting colonial staple, and as the

rescue from the ruin which appeared imminent to the proprietors of the vineyards, especially in the south. Parmentier was, among the scientists and members of the Institute, the leader of this movement and the promoter of this apparent germ of a new industry and internal source of national wealth, and he published a work entitled, "*Traité sur l'art de fabriquer les sirops et conserves de raisin.*" The methods he indicated in this work were mainly followed in the experiments of 1808 and 1809, but were considerably improved upon by Proust and Fouques. They served, however, in the various southern departments of the empire, for the production of considerable quantities of sirup from the vintages of 1808 and 1809, samples of which were presented to the minister of the interior, who at once called the attention of the Emperor to the results represented in the samples in the following report, which will serve to show not only the condition of the enterprise at the close of 1809 and the beginning of 1810, but also what had been done previous to that time and the appreciation with which he regarded it; and the decree of Napoleon issued in consequence of this report will show the interest he had in this possible source of a substitute for the colonial staple. The report appeared in the *Moniteur* of June 23, 1810. The minister, Montalivet, says:

SIRE: I have reported to your Majesty the successes obtained by M. Parmentier, who has given very useful attention to perfecting grape sirup and making it suitable to replace cane sugar in many medical and domestic preparations. Your Majesty, who ordered it to be used in the palace, seemed satisfied with it. I desire to-day to fix your attention upon more important results. M. Proust, an able chemist, has extracted from grape sirup a concrete sugar. M. Fouques has found a means of bleaching it and giving it not only the brilliancy but also the consistency and color of cane sugar. I have called together a commission, composed of Messrs. Berthollet and Chaptal, Senators, and members of the Institute, Parmentier, Vauquelin, and Proust. The sugar of M. Fouques was submitted to them for examination. The commission decided that this substance was worthy of the highest degree of attention, and after having made some tests upon the substance itself, without any preparation, thought it especially essential to determine what would be its effects in different mixtures and different proportions. The commission then adjourned, and came together again at the ministry on the 12th of this month.

The commission found that couderves containing the triple and quadruple of grape sugar were too sweet. Those containing the double were less sweet than those containing a single proportion of cane sugar. That the grape sugar equivalent of cane was a little over $2\frac{1}{2}$ to 1.

MONTALIVET.

"In consequence of this report of the minister of the interior, His Majesty issued, under date of June 18, 1810, the following decree:

ARTICLE 1. There is accorded the sum of 100,000 francs (\$20,000) to M. Proust,* and one of 40,000 francs (\$8,000) to Sieur Fouques, in the form of gratuity and by way of encouragement for the discovery they have made of grape sugar.

ART. 2. They shall be obliged to use these two sums to establish grape-sugar factories in that portion of our southern departments designated by our minister of the interior.

* By decree of June 21, 1810, Napoleon appointed M. Proust, chemist, member of the Legion of Honor,

ART. 3. They shall be obliged to give up the secret of their processes, which shall be rendered public, and be sent to all the prefects of our grape-growing departments.

ART. 4. From January 1, 1811, at the latest, the sugar of grapes shall replace in all public establishments the sugar of canes.

ART. 5. Our minister of the interior shall recommend to the prefects to propagate and encourage the establishment of factories for either grape sirup or concrete grape sugar, so that in the coming year the inestimable advantages of this precious discovery shall make itself felt for the good of all our people and the interests of our commerce.

“The same commission to whom was submitted for examination the samples of sirup and sugar produced by Messrs. Proust and Fouques were directed by the minister of the interior to prepare detailed instructions upon the methods to be followed for the successful and profitable extraction of sirup and concrete sugar from grapes, and the result of the work they at once entered upon, a copy of which may be found in the *Moniteur* of August 25, 1810, was printed and distributed throughout the grape-growing departments of France, in company with the following circular letter to the prefects of those departments, under date of August 18, 1810:

MONSIEUR LE PRÉFÊT: His Majesty the Emperor desires to give an impulse to the manufacture of sugar and sirup from grapes, and he has ordered that there be prepared to this effect simple instructions indicating the best processes to follow. He wishes that the instructions prepared by the most celebrated savants, and generally distributed, may lead proprietors to make sirup and sugar for their own uses, and place manufacturers in the way of making it in the surest and most economical manner, and completely supplying the markets with products from the next vintage.

I send you several copies of these instructions. Be so good as to distribute them to your officers who will make the best use of them, and cause them to be printed in the journal of your department.

You must not content yourself with causing the description of the process of manufacture of sugar and sirup from grapes to be distributed to even the smallest communes; you shall stimulate the zeal of your officers; you shall promise and accord prizes to those who shall have made the most of sugar and sirup of the best quality. I will supply, upon your requisition, the funds you may dispose of.

I also invite you to immediately confer with directors of hospitals and other charitable establishments of your department, that they in turn may confer with farmers, proprietors, and pharmacist who may desire to make sirups and sugars, and arrange with these persons such markets as will assure the sale of the products of this year. You shall preside over these arrangements, and take care that, without injuring the interests of the poor, there may be all-sufficient encouragement for manufacturers.

You shall address to me a table of the quantities of sugars and ordinary sirups annually consumed in each hospital, and of the presumed consumption of the coming year in sirups and sugars of grapes, with indications of the markets which have been recorded.

The subprefects and mayors will, I hope, second you in all your efforts. You shall make known to me those functionaries and special persons who shall be most distinguished in this sphere of usefulness which is open to them. I shall report their efforts and their success, as well as your own, to the Emperor.

Let manufacturing establishments multiply everywhere. Let it be considered, M. le Préfêt, that this is a sort of war we are making against the enemies of the Continent, and which his Majesty considers, more than any other sovereign, worthy of recompense to those who make themselves prominent in the ranks.

Count MONTALIVET,
Minister of the Interior.

“Immediately after this the Emperor issued the following decree, ddate August 22, 1810:

Considering that the economical manufacture of sugar from grapes essentially influences the prosperity of agriculture and commerce, and desiring to give to this important branch of the industry a particular mark of our special protection, we have decreed and do decree as follows:

ARTICLE 1. On June 1, 1811, the sum of 200,000 francs (\$40,000) shall be distributed among twelve establishments which shall have made the largest quantity of sugar from grapes.

ART. 2. The distribution shall be made among the twelve establishments proportionally to the quantity of sugar that each one shall have made.

ART. 3. To secure the right of competition it shall be necessary to have made at least 10,000 kilograms (22,000 pounds) of sugar.

ART. 4. The quantities of sugar made shall be verified by a commissioner appointed for that purpose by the prefect of the department and certified to by the mayor of the place.

ART. 5. The prefect shall address these evidences to our minister of the interior before May 1, 1811. He shall also send at the same time a sample of the sugar made.

ART. 6. Our minister of the interior shall make to us a report to this effect. He shall make known to us at the same time the manufacturers who have perfected the processes of manufacture and shall propose to us the recompenses and encouragements they shall have merited.

“But while these encouragements were being given to the enterprise of producing sirup and sugar from grapes in the south to replace the colonial staple in the home consumption of France, the results of Achard’s later work, as described in his letter to the editor of the *Moniteur* in 1808, had awakened anew the interest in the beet root as a source of sugar in the north, and M. Deyeux, reporter of the first committee of the Institute, which conducted the experiments of 1800, in compliance with a request made through the Institute by the minister of the interior, again undertook to repeat in 1809 and 1810 the experiments of the former committee, and the later work of Achard, with such modifications as he deemed advisable and practicable. In this work he was associated with Mr. Barruel, chief of the chemical department of the School of Medicine of Paris, and their labors were rewarded by the production of a certain quantity of muscovado, which they refined and thus secured ‘two loaves of sugar, perfectly crystallized, of great whiteness, brilliant and sonorous, in a word enjoying all the properties of the finest cane sugar,’ one of which was presented by the minister of the interior to the Emperor, who is said to have ‘received it with that benevolence which he accords to every useful object.’ But these experiments, while they showed the practicability of extracting sugar from the beet root by the means proposed, were still not of a character to show the net cost of producing the sugar, because the experiments viewed the work only in a chemical sense. Messrs. Barruel and Isnard then undertook to determine this part of the question, and repeated these experiments just mentioned, keeping strict accounts of the cost of each stage of the processes applied and the quantities of the products obtained. It was found that by their processes they were able to extract 1.5 per cent. of muscovado, which

cost 30 cents per pound. The refined sugar produced from this lower grade cost 40 cents per pound. It appears, however, that the beets treated, which were grown upon the highly manured lands of the plain of Vertus where their works were located, were very unfavorable to the results of the experiments. It also appears that these figures represent the actual cost to the experimenters in the extraction of the sugar, taking no account of the by-products and assigning the maximum price for the beets worked; but the further estimates of cost made up by Messrs. Barruel and Isnard, based upon their own experiments and working by their own processes, supposing the value of the beets to be the actual cost of producing them and the amount of roots handled to be the yield of about 400 acres of land, about 6,000 tons, show that the cost of production should not exceed 8 cents per pound for good muscovado, or 12.9 cents per pound of refined sugar.

"The actual condition of the sugar enterprise in France at the close of 1810 may be gleaned from the following report to the Emperor by Montalivet, under date of January 10, 1811.

The production of sirup and sugar from grapes ordered by your Majesty is pursued with activity; and even though the season has not been very favorable to the vine, I am in daily receipt of proofs of the zeal with which a large number of proprietors are animated in the different departments, but those of the south and the center are the only ones who may engage in this manufacture, and on this account I would respectfully submit to your Majesty the results which lead us to hope that even the departments of the north may find upon their territory a sugar of very good quality. We know that for some years back beet-root sugar has been manufactured at Berlin and Breslau. Messrs. Achard and Koppy addressed to my predecessor very beautiful specimens of this sugar, but up to the present but slight results have been obtained. M. Deyeux, first pharmacist to your Majesty and member of the Institute, has just re-undertaken this work and has obtained very remarkable success in the results which he has addressed to me, and which I submit to your Majesty. He has also addressed to me an interesting memoir in which he has reported to the Institute the processes he employed to arrive at his results. He believes these processes to be more simple and better than those adopted by Messrs. Achard and Koppy. But M. Deyeux, obliged to devote himself to trials and experiments to find a good method, is unable as yet to establish the price at which this sugar can be produced. Everything shows, however, that this price will be sufficiently low to prove a large source of profit to extended manufacture. Already, in the department of the Doubs, a rich proprietor, Mons. Secci, has established a manufacture of this kind and has sown 80 acres in beets, which have yielded him 500,000 kilograms (500 tons) of roots, from which 25 to 30 milliers (27,500 to 33,000 pounds) of refined sugar may be expected. The prefect of Mont Tonnère has also informed me that Mons. Molar, a proprietor in his department has sown 80 hectares (197.6 acres) of ground in beets which he proposed to convert into sugar, and for which operation he asks to be admitted to the prizes which your Majesty has deigned to promise to manufacturers of sirup and sugar from grapes. In the department of Roer, the manufacturer of sugar from beet roots is carried on by the brothers Herberm at Urduiger. The prefect of the Rhine and Moselle has transmitted to me samples of a very fine cassonade from beet roots, manufactured by Mons. Anthonin, who asks for encouragement to enable him to enter upon this manufacture on a large scale. Finally, for Holland, the prince governor-general has sent me a sample of beet-root sugar made by M. Linden at Hemmer, in whose labors he appears to have confidence; and the prefect of the Bouches-du-Rhône has shown me samples of beet-root sugar made by M. Vanroggen, one of his officers.

I shall, at a later date, report to your Majesty the results which these different attempts promise. At this time, I confine myself to presenting the sugar made by M. Deyeux. It in no way differs from the refined sugar of the colonies. This test shows what may be expected from this work as regards the quality of the material. I shall now study carefully the means of determining to what extent this manufacture may become economical and the measures to be taken to render it general in the departments of the north.

MONTALIVET,
Minister of the Interior.

"It is to be remarked further that prizes were also offered by the Société d'Encouragement pour l'Industrie Nationale for the production of sugar from grapes or beets, the annual prize being 2,400 francs (\$480) for the best essay and sample, 1,000 francs (\$200) for second best, and, on February 20, 1811, it received, through its founder and then president, Count Chaptal, a memoir upon the methods for the extraction of sugar from beets, by M. Drappiez, a pharmacist at Lille, together with a loaf of the sugar, of which he had been able to obtain 50 quintals by the method he described. The committee on chemical arts of the society compared the sample submitted by M. Drappiez with a sample of refined cane sugar they were then able to obtain at a cost of 95 cents per English pound, and failed to detect the "*slightest difference*" between them. M. Drappiez obtained by his method a yield of 1.3 per cent., the cost of which he estimated at 80 cents per pound.

"Shortly after this there appeared in the *Moniteur* of March 23, 1811, a statement to the effect—

That there had been presented to his Majesty several quintals of refined crystallized beet-root sugar, having all the qualities of that of the cane; loaves of both kinds have been mixed together, and it was impossible to distinguish between them. It follows from the report of a commission charged with the examination of the different means proposed to replace by indigenous processes the foreign productions so costly to France, that 70,000 acres cultivated in beet roots would furnish the 30,000,000 of pounds necessary to our consumption.

"And two days later Napoleon issued the first decree, in which he provided for direct encouragement of the beet-sugar industry, and which was as follows:

PALACE OF THE TUILLERIES, *March 25, 1811.*
NAPOLEON, *Emperor of the French, etc.:*

Upon a report of a commission appointed to examine the means proposed to naturalize, upon the continent of our empire, sugar, indigo, cotton, and divers other productions of the two Indies:

Upon presentation made to us of a considerable quantity of beet-root sugar, refined, crystallized, and possessing all the qualities and properties of cane sugar:

Upon the presentation made to us at the council of commerce of a great quantity of indigo, extracted from the plant woad, which our departments of the south produce in abundance, and which indigo has all the properties of the indigo of the two Indies:

Having reason to expect that by means of these two precious discoveries our empire will shortly be relieved from an exportation of 100,000,000 francs (\$20,000,000) hitherto necessary for supplying the consumption of sugar and indigo:

We have decreed and do decree as follows:

ARTICLE 1. Plantations of beet root proper for the manufacture of sugar shall be formed in our empire to the extent of 32,000 hectares (79,040 acres).

ART. 2. Our minister of the interior shall distribute 32,000 hectares among the departments of our empire, taking into consideration those departments where the culture of tobacco may be established, and those which from the nature of the soil may be more favorable to the culture of the beet root.

ART. 3. Our prefects shall take measures that the number of hectares allotted to their respective departments shall be in full cultivation this year, or next year at the latest.

ART. 4. A certain number of hectares shall be laid out in our empire in plantations of woad proper to the manufacture of indigo in the proportion necessary for our manufacture.

ART. 5. Our minister of the interior shall distribute the said number among the departments of our empire, taking into particular consideration the departments beyond the Alps and those of the south, where this branch of industry formerly made great progress.

ART. 6. Our prefects shall take measures that the number of hectares allotted to their departments shall be in full cultivation next year at the latest.

ART. 7. The commission shall, before the 4th of May, fix upon the most convenient places for the establishment of six experimental schools for giving instruction in the manufacture of beet-root sugar conformably to the processes of chemists.

ART. 8. The commission shall also, before the same date, fix upon the places most convenient for the establishment of four experimental schools for giving instruction upon the extraction of indigo from the lees of woad according to the processes approved by the commission.

ART. 9. Our minister of the interior shall make known to the prefects in what places these schools shall be formed, and to which pupils destined to this manufacture should be sent. Proprietors and farmers who may wish to attend a course of lectures in the said experimental schools shall be admitted thereto.

ART. 10. Messrs. Barruel and Isnard, who have brought to perfection the processes for extracting sugar from the beet root, shall be specially charged with the direction of two of the six experimental schools.

ART. 11. Our minister of the interior shall, in consequence, cause to be paid the sum necessary for the formation of the said establishments, which sum shall be charged to the fund of 1,000,000 francs (\$200,000) in the budget of 1811 at the disposal of the said minister for the encouragement of beet-root sugar and woad indigo.

ART. 12. From the 1st of January, 1813, and upon a report to be made to our minister of the interior, the sugar and indigo of the two Indies shall be prohibited, and considered as merchandise of English manufacture or proceeding from English commerce.

ART. 13. Our minister of the interior is charged with the execution of the present decree.

“Early in the following April, 1811, Decostils, reporter of the committee on chemical arts of the Société d’Encouragement pour l’Industrie Nationale, reported upon a memoir and results presented by M. Derosne. He was the first to suggest the use of quicklime in the purification of the juice. His method was based upon three principal points: (1) The use of caustic lime; (2) the use of alum; and (3) the use of alcohol. The lime he adds to the fresh juice, of which he succeeded in expressing 63 per cent. the weight of the root. The proportion added was 0.24 gram per liter of juice. After the addition of lime in a thick milk the juice was rapidly brought to boiling and the scums removed as they formed. The juice was then separated from the sediment, which

settled and concentrated. It was then purified with alum and blood, and further treated in the usual way. The proportion of sugar extracted by this method is stated to have been $4\frac{1}{2}$ per cent., and was the highest result that had yet been attained. The beets from which this high yield was obtained were of the white Swedish variety, while the beets of the plain of Aubervillier did not yield as much by $2\frac{1}{2}$ per cent.

"After the announcement of this method of Derosne it appears that little was published on the subject of the new industry, that was now beginning to assume important dimensions, until the beginning of the following year, when Montalivet reported to His Majesty that 6,785 hectares (16,758 acres) had been sown in beets in different departments of the empire, producing 98,813 tons of roots.

"The number of factories established was thirty-nine or forty, and the minister estimated that if the whole product were worked up the result would be 1,500,000 kilograms (3,300,000 pounds) of sugar; but the plantations were in many cases too far removed from the factories to make it possible to transport the roots with profit. He also gave a table showing the number of hectares sown in beets in each department, the quantity of roots harvested, and the reasons which prevented more extensive planting in each. The latter seemed to be principally lack of sufficient seed and lateness of the season.

"About the same time a report was made to the Emperor by Count Chaptal showing the cost, by the methods then known and in use, of the culture of the beet and the manufacture of sugar. The first he estimates at 176 francs per metrical arpent (about \$35 per acre), the yield of which varies from 12,000 to 45,000 to 50,000 pounds. The second cost he estimated at 15 cents per pound, supposing all the molasses to be sold; but if no molasses be sold then he estimates that the cost would reach 30 cents per pound. For the cost of refined sugar he makes two estimates; the first supposing 15 cents per pound as the value of the raw sugar, and in the second he values it at 30 cents. According to the first supposition the cost would be 32 cents per pound, and $45\frac{1}{2}$ cents according to the second supposition.

"In concluding his report, Chaptal says an intimate knowledge of chemistry is necessary for successful work; and he recommends, as a means for assuring the prompt prosperity of this enterprise, that there be established at one of the factories already established a normal school, and that there be brought together there thirty or forty young men already versed in chemical knowledge, and forty others taken from among the children of refiners of Orleans, Antwerp, Ghent, Marseilles, Nantes, Amsterdam, etc., and from among the chiefs of refineries in the larger towns; and the establishment at which, it seemed to him, such instruction as he referred to could be given was that of M. Barruel, in the plain of Vertus.

"On the 12th of January, 1812, M. Barruel published a note upon the manufacture of beet-root sugar, and describes the method he had finally

devised for extracting the sugar, and in this description we find the first mention of the use of carbonic acid for separating the excess of lime remaining after purification of the juice. He proceeds as follows: The juice is heated to 65° R.; milk of lime is then added (295 grams quicklime per 100 kilograms of juice, or 295 parts in 100,000); the whole stirred thoroughly and heated to 80° R. The coloring matter, etc., forms in soluble compounds and makes a flocculent precipitate. A solid scum forms on the top. The latter is skimmed off and the liquid decanted. The clear juice is then freed from lime, and for this purpose an acid which forms an insoluble compound with the lime is the best, sulphuric or carbonic acids preferred. Alum may be used according to Derosne's method, but this only acts by the sulphuric acid it contains, and while for equal weights sulphuric acid costs more than alum, it will neutralize more of lime.

"M. Barruel considers, however, that carbonic acid is the most economical of all, and for his purpose he prepares it by passing air through burning coals.

"In the conclusion of his note he says: 'This process, which is very simple and not costly, always succeeds. I guaranty its exactness and success.'

"Maumené states that about this time Napoleon visited a factory at Passy, where Benjamin Delessert had succeeded in producing white sugar from beets, and after having given him the cross of the Legion of Honor (the same which ornamented his own breast) as a recompense for this splendid initiative, the Emperor caused to be inserted in the *Moniteur* of the following day the grand evolution that had been consummated in French commerce. But of this circumstance we are unable to find any record in the *Moniteur* or the *Journal de l'Empire* of that period.

"On January 15, 1812, Napoleon issued the following decree, in all probability a result of the report made by Count Chaptal:

SECTION I.—SCHOOL FOR MANUFACTURE OF BEET-ROOT SUGAR.

ARTICLE 1. The factory of Messrs. Barruel and Chappelet, plain of Vertus, and those established at Wachenheim, department of Mont-Tonnère, at Douai, Strasbourg, and at Castelnaudary, are established as special schools for the manufacture of beet-root sugar.

ART. 2. One hundred students shall be attached to these schools, viz: Forty at that of Messrs. Barruel and Chappelet, and fifteen at each of those at Wachenheim, Douai, Strasbourg, and Castelnaudary; total, one hundred.

ART. 3. These students shall be selected from among students in medicine, pharmacy, and chemistry.

SECTION II.—CULTURE OF BEETS.

ART. 4. Our minister of the interior shall take measures to cause to be sown throughout our empire 100,000 metrical arpents of beets. The conditions of the distribution of the culture shall be printed and sent to the prefects previous to February 15.

SECTION III.—MANUFACTURE.

ART. 5. There shall be accorded throughout our entire empire five hundred licenses for the manufacture of beet-root sugar.

ART. 6. These licenses shall be accorded of preference—

To all proprietors of factories or refineries.

To all who have manufactured sugar during 1811.

To all who have made preparations and expenditures for the establishment of factories for work in 1812.

ART. 7. Of these licenses there shall be accorded of right, one to each department.

ART. 8. Prefects shall write to all proprietors of refineries, in order that they may make their submissions for the establishment of the said factories at the close of 1812. In default on the part of proprietors of refineries to have made their submissions prior to March 15, or at the latest April 15, they shall be considered as having renounced the preference accorded them.

ART. 9. Licenses shall include an obligation on the part of those who shall obtain them to establish a factory capable of producing at least 10,000 kilograms (22,000 pounds) of raw sugar in 1812-'13.

ART. 10. Each individual who, having received a license, shall have actually manufactured nearly 10,000 kilograms of raw sugar resulting from the crop of 1812 to 1813 shall have the privilege and assurance, by way of encouragement, of being subject to no tax, or *octroi*, upon the product of his manufacture for the space of four years.

ART. 11. Each individual who shall perfect the manufacture of sugar in such a manner as to obtain a larger quantity from the beet, or who shall invent a more simple and economical method of manufacture, shall obtain a license for a longer time, with the assurance that no duty nor *octroi* shall be placed upon the product of his manufacture during the continuance of his license.

SECTION IV.—CREATION OF FOUR IMPERIAL FACTORIES.

ART. 12. Four imperial beet-sugar factories shall be established in 1812 under the care or our minister of the interior

ART. 13. These factories shall be so arranged as to produce with the crop of 1812 to 1813, 2,000,000 kilograms of raw sugar.

“We find one of the practical results of this generous decree in the announcement made by Charpentier *frères* of Valenciennes, Département du Nord (Journal de l'Empire, of December 2, 1812), that they had for sale 12,000 kilograms (26,400 pounds) of beet-root sugar manufactured from the crop of that year, and during the first two months of work. The large quantity of beets they still had in store assured them, it was stated, for the end of April, 1813, a product of 60,000 kilograms (132,000 pounds), which they offered to sell as it should be made.

“But these results are more fully described by the minister of the interior, in his report upon the situation of the empire in the beginning of 1813, in which, under the head of new industries, he says:

To replace in our consumption the sugar, indigo, and cochineal of the colonies; to find in the south of Europe and at home the cottons and soda to supply our manufactures seemed impossible. It was ardently wished for, and the impossibility disappeared before our efforts.

During this year the manufacture of sugar which is extracted from the beet root will give us 7,700,000 pounds of this staple. It is prepared in three hundred and thirty-four factories, all of which are in actual activity.

After numerous trials, processes are finally employed by which beet-root sugar will not cost more than 15 cents per pound to the manufacturer. Mr. Boumatin, in-

ventor of this new method, profited by the useful labors of his predecessors, and the government, in order to hasten the fortunate results of his discovery, charged him to proceed to propagate it in those sections in which the principal manufactories are established.

Since the establishment of the high price of sugar, consumption has greatly decreased, and the 7,000,000 pounds manufactured at this time may be considered equal to at least one-half our actual needs. This diminution is not the result of any absolute privation that may have occurred, but from the equivalents by which sugar has come to be replaced.

Several millions of pounds of sirups from grapes and honey, the latter better purified and more abundant, have been substituted for sugar in a great portion of the domestic uses with so much of ease that the most delicate taste could scarcely perceive the change.

When the difficulty of procuring sugar and its cost shall be less; when the first profits, at present so great, if they be considered only as interest upon capital, shall have covered the cost of establishing, the quantity that will be consumed will again increase, the equilibrium will be renewed, and supposing that one-fifth the consumption to remain definitely replaced by sirup of grapes and honey, France will consume 40,000,000 pounds of beet-root sugar, the value of which will be 30,000,000 francs, and we may count upon these results for 1814. Our refineries now yield a product of 10,000,000 pounds, which will increase to at least 20,000,000 pounds.

In the six years beginning with 1802, we received from abroad an annual average of 52,000,000 pounds of sugar. During the four years beginning with 1809, the average annual importation has been but 10,000,000 to 11,000,000 pounds. It is especially since that time that nothing has been neglected to naturalize this staple at home, and the conquest is finally assured.

“But while all this interest and busy enterprise was being manifested in France, great progress was also being made in Germany. And the generous and worthy action of Napoleon in extending substantial encouragement to the development of the growing industry which produced such happy results had even been anticipated by the German Government, which came to the aid of Achard, who had for nearly fifteen years devoted all his time and limited means to the development and establishment of the industry, in the ultimate success of which, in spite of all the reverses to which he had been subject, he had never lost faith. His influence and example had led to the establishment of the works of Baron de Koppy at Krayn, and his watchful care over it had assured its financial success. And this besides those already mentioned was followed by the establishment of works in other sections, notably by Baron von Lorentz, Counselor Mengen, and more especially the Messrs. Mayer, of Breslau, who, we are told by Isnard, director of the special school of chemistry for beet-sugar manufacture at Strasburg, had for ten years sown about 750 acres in beets. In view of the progress attained and the interest manifested, the governmental authorities accorded to Achard, during the course of 1810 and 1812, the encouragement and aid indicated in the following notice sent by Achard to the *Moniteur*, and published in that journal, June 23, 1812, showing also the progress this pioneer in the industry had made. He says:

The public has, during the past year, been informed, as much by the decrees of the regency of Silesia as by the several writings I have published, that His Majesty, the

King of Prussia, has ordered me to establish on my two estates of Upper and Lower Cunern, near Wohlen, in Lower Silesia, a practical school for instruction as complete as possible, to make known to our people as well as to foreigners the processes employed in the extraction of sugar from beet roots.

"He further states that he had three distinct methods for extraction, using neither lime, carbonate of lime, milk, sulphuric acid, nor alum, except for beet of poor quality, or toward spring when vegetation has commenced. By the new method he succeeded in getting concrete sugar in twenty-four hours. The three methods of separating the sugar from sirups of beet juices are: (1) by regular crystallization; (2) by granulation; (3) by immediate conversion into bastard sugar. By the first method 1 quintal of juice gives 5 Silesian pounds of sugar. By the second 6 pounds are obtained, and by the third method, which is preferable to all others, the sugar may be extracted in twenty-four hours, yielding 5 pounds of raw sugar.

"This notice of Achard is followed by one from the Royal Regency of Silesia, upon the establishments of Achard, stating that—

His Majesty the King of Prussia, in giving to M. Achard a considerable sum of money, prescribed that he should establish and maintain upon his estate, and at his own cost, a factory for instruction in the manufacture of sugar from beets.

In the month of December of last year (1811), Achard having announced to the Royal Regency that he had established two factories—one factory on a small scale and such as could be united with farm management, the other to manufacture sugar on a large scale; that the building for lodging students was finished and ready to receive them; that the course of instruction would commence in January; and that he would be flattered to see an official examination of his work—we consequently appointed for this purpose two intelligent persons, who found that the buildings intended for the manufacture were actually completed, and provided with the apparatus and machinery necessary. It also appears from this report that since January 12 (1812) the manufactory has been in full activity, and that besides the students there were employed in the factory a foreman, nine male, and four female laborers. During the course of instruction 20 quintals are worked upon daily. Five pounds of raw sugar per quintal [110 pounds] are extracted, and, according to exact calculations made at the factory, it follows that 100 quintals of beets give a net profit of something more than 111 thalers current money.

"This model factory and school of Achard attracted students from nearly all the nations of the continent, and it is probable that it was the students he had from Russia who carried back to their country the germs of this industry, which has now become so powerful there, and which in that country received its establishing impulse through the aid and encouragement extended by the imperial authority; for it is related that General Blankenagel, who founded a factory in the government of Toula, at the village of Akabef, had received from the Ozar of Russia a gift of 50,000 roubles (\$38,895), and that an ukase or edict of the emperor gave the assurance that all lands of those establishing sugar factories should be free from tax.

"Such, then, was the progress attained in this new and valuable industry, and its condition in the beginning of 1814, during which memorable year what had bid fair to be a great source of national wealth and

prosperity to all the continental nations received almost its death-blow. The beginning of the war with Russia interfered with its progress in that country. The destructive passage of foreign and contending armies destroyed completely not only this, but other and more flourishing industries in Germany, and the final conflict on French territory and the downfall of Napoleon, who has been described as the second father of the industry, resulted in its almost complete extinction in France, and the withdrawal on the part of the immediate successor of the great Emperor of the encouragement he had accorded was nearly as disastrous as had been the malicious depredations which were perpetrated by the enemy's troops, and it required the patient labor of more than another decade to accomplish what Napoleon had been able to establish in about one-third that time.

“But it must not be supposed that this new enterprise, which had assumed such formidable proportions, was during its development favored with a constant belief of the entire people of all nations in its value and its efficacy to supply a substitute for the staple of the tropical climes, which had formed the basis of much of the maritime commerce of the time. If Achard received ridicule at home and was looked upon by many of his countrymen as an insane enthusiast, but which prejudice by presentation of substantial evidences he was able to dissipate, the criticisms heaped upon Napoleon were of the bitterest character abroad, and the mutterings which could not under imperial rules enjoy unrestrained expression were not unknown to him, nor did they in any way affect the firmness of his resolution or his charity toward his critics at home, as is shown in the following address he made to the chamber of commerce March 11, 1811, in which he says :

The Berlin and Milan decrees are the fundamental laws of my empire as regards neutral commerce. I consider the flag an extension of territory, and the nation which suffers it to be violated shall not be considered neutral.

The fate of American commerce shall soon be decided. I will favor it if the United States will conform to these decrees; on the contrary, their ships will be excluded from my empire.

Commercial relations with England must cease. I proclaim it to you, gentlemen, distinctly. Merchants who have transactions there to settle or funds to withdraw should do it as quickly as possible. I gave this advice some time ago to the merchants of Antwerp, and they have profited by it.

I wish for peace, but not a patched-up one. I wish for it sincerely, and for such an one as will afford me sufficient guaranties, for I have not lost sight of Amiens or St. Domingo, or the losses which commerce sustained from the last declaration of war.

* * * * *

I have a knowledge of what is passing in the counting-houses of merchants. I know they denounce in high terms my measures and say I am badly advised. I will not blame them for their impressions, because, not having a view of the whole ground, they have not an opportunity to calculate and judge as I do. Nevertheless, those who have lately arrived from England will inform you of the injurious consequences produced in that country from an interruption of their commerce with the Continent, and may say it is possible I am right and that my designs may be accomplished.

* * * * *

I am informed that from late experiments France will be enabled to do without the sugars and indigoes of the two Indies. Chemistry has made such progress in this country, that it will possibly produce as great a change in our commercial relations as that produced by the discovery of the compass. I do not say, gentlemen, that I do not wish for maritime commerce or colonies, but it is proper to abandon them for the present, and until England shall return to just and reasonable principles, or until I can dictate to her terms of peace.

* * * * *

I know the English have better admirals, and that is a great advantage, but by often fighting them we shall learn to conquer.

* * * * *

The vent of colonial produce upon the Continent being once firmly shut, the English will be obliged to throw into the Thames the sugars and indigoes for which they have exchanged objects of their industry, and which have afforded them such resources.

“It is stated that about this time a caricature was exhibited in Paris in which the Emperor and the King of Rome were the most prominent characters. The Emperor was represented as sitting in the nursery with a cup of coffee before him, into which he was squeezing a beet-root. Near him was seated the King of Rome voraciously sucking the beet-root, while the nurse, standing near and steadfastly observing, is made to say to the youthful monarch, “*Suck, dear, suck ; your father says it is sugar !*”

“But as the doubt and ridicule here indicated gave way to a large extent in France before the development of the industry, that expressed in the English journals also gave place to an undercurrent of anxious inquiry as to the possible fate of the English colonial commerce, and the probable extent of the development of the new industries that were being so ardently fostered by Napoleon ; and it is related by the Prince Louis Napoleon that the English Government even made anonymous offers to Achard, first of the sum of \$40,000, and later on of \$100,000, if he would publish a work declaring that he had been carried away by his enthusiasm in his former publications, and that the results he then made public had by no means been confirmed by his later work. Failing in effecting in this way the result desired, it is said the Government induced Sir Humphrey Davy to write a brochure, in which he declared that, while sugar could be produced from the beet, the product was too bitter for consumption.

“But the impotency of these attacks upon the new industry is fully illustrated in its subsequent history. Napoleon, in his wisdom, continued his substantial encouragement of this and other agricultural and manufacturing industries in France by the appropriation of several millions of francs in their support at a time when the total revenue of his empire did not exceed 999,000,000 of francs (less than \$200,000,000) and he was maintaining large armies in Spain and Portugal, and a very formidable navy on the high seas.

“But if the industry Napoleon had fostered and established fell with his downfall, its value had been demonstrated, and was even admitted in the first report of the Abbé de Montesquieu, minister of the interior

under Louis XVIII, a report filled with the bitterest criticisms of the policy of the Imperial Government, accusing it of tyranny and imposition upon the rights of the people as concerns the manufacturing interests. In the course of this report the minister remarked that—

Mechanics and chemistry, enriched by a crowd of discoveries and ably applied to the arts, had caused rapid progress. The continental system, by forcing manufacturers to seek upon our own territory hitherto unknown resources, brought about some useful results.

“The condition in which the wars left France and her industries at the beginning of 1815 necessitated the production of the revenue for the support of the government from external sources, for her fields and factories could not then bear a tax sufficient for the purpose. The customs duty this required maintained the prices of colonial staples at rates even higher than those which prevailed during the preceding reign, and operated as a substitute for the encouragement before given by the Government. It was on this account that the one factory, that of M. Crespel, at Arras, in the department of the North, which had survived the general wreck, was able in a year or two to yield to its enterprising owner and director a fair income with which to retrieve his broken fortune, and to again extend the industry in which it was shown he had such a deep interest. With the profits attained by one factory he established another until he finally became the proprietor of ten of the finest works of his time. His intelligence, industry, and enterprise gave an impetus to the culture and manufacture of the crop, and his example was soon followed by others in different parts of the country, and factories were established and worked with varying success. In 1823, Dubrunfaut published, in his work on the manufacture, information concerning the condition of the industry at that time, that he had been able to obtain on a tour among the principal factories of the day. From this work we gather the facts and figures tabulated below concerning the cost of culture of the beet and of the manufacture of sugar by some of the most progressive and successful manufacturers he had occasion to visit.

Name of grower.	Yield per acre in tons of 2,200 pounds.	Cost per ton of roots.
Mathieu de Dombasle.....	5.06	\$5.80
Count Chaptal.....	12.45	3.68
Crespel.....	10.12	3.00
Cafier.....	12.145	2.66
Duke of Ragusa.....	10.12	3.36
General Preval.....	6.356	3.60
Masson.....	6.680	3.44
Audré.....	7.247	3.18
Grévet-Pélé.....	10.777	2.50
Demars ..	15.222	4.00
Average.....	9.611	3.52

MANUFACTURE.

Name.	No. of days' work per annum.	Tons worked.	Yield in sugar.	Sugar per 100 of roots.	Cost.			Price paid for roots.
					Total.	Per ton of roots.	Per pound of sugar.	
			<i>Pounds.</i>				<i>Cents.</i>	<i>Per ton.</i>
Chaptal.....	120	600	.....	3.0	.....	.....	11.8	\$4.00
M. de Dombasle	150	2,250	99,000	2	\$27,656	\$12.29	27	6.05
Duke of Ragusa	120	1,000	82,500	3.75	87,000	8.70	9.9	4.00
Crespel .....	.....	2,000	.....	5	.....	.....	5.6	3.00
Caffier.....	150	1,000	.....	.....	.....	.....	6	.....

“DuBrunfaut determines from his own observations as the cost of production 5.2 cents per pound avoirdupois for the intermittent process, and 4.8 cents for the continuous. Colonial sugars were at this time worth 1.40 to 1.50 francs per kilogram, or 12.7 to 13.6 cents per pound, and it was stated to be impossible to produce them at a cost of less than 5.5 cents per pound in the Antilles.

“The above estimate of cost given by DuBrunfaut was for working about 1,000 tons per annum. For working double that quantity the net cost appears at that time to have been greater, and reached 5.8 cents for the intermittent process and 5.4 for the continuous process.

“From this time the industry continued to spread rapidly, and to produce everywhere fruitful and profitable results, though, strange to say, no record seems to have been kept of the statistics of production in France until the year 1829, when it was stated at 4,000 tons.

“In Germany the industry did not revive until after 1835, when attention was called to it by Krause of Austria, and Schubarth of Prussia, who went to France, the first in 1834 and the second in 1836, to study the progress and condition of the manufacture. As a consequence of these trips and the prominence given by the press of the information they carried home with them, the culture of the beet was inaugurated anew, factories were again erected in large numbers, and the industry soon became so powerful as to be competent to contribute to the revenue of the Government.

HISTORY AND PROGRESS OF THE CULTURE OF THE SUGAR-BEET AND THE MANUFACTURE OF SUGAR THEREFROM IN THE UNITED STATES OF AMERICA.*

"Notwithstanding the progress that has been made in Europe in the culture of the sugar-beet and the manufacture of beet-root sugar, and immensity and value of the industry it has supplied to European nations, the knowledge and experience resulting has not been applied in such a way in the United States as to make the production of sugar from this source a matter of any commercial or industrial importance, although attempts at the introduction of the industry have not been wanting. In most cases the attempts, which have had varying success or rather failure, seem to have been originated and guided by enthusiasm rather than by sound judgment, based upon a previous close study of all the conditions which should influence or absolutely govern the success or failure of the enterprise. This is very evident from a review of the records we have of the various experiments which have been made both on a large and a small scale.

"The first experiment, made by two enterprising Philadelphians as early as 1830, was almost cotemporaneous with the final firm establishment of the industry in France and the great interest manifested in it there, but it seems that these gentlemen were wholly ignorant of the requirements either of the culture of the root or the extraction of sugar, and failure was the natural result of their efforts.

"Eight years later, David Lee Child, who had spent a year and a half in the beet-growing districts of Europe in careful study of all the requirements, both of culture and manufacture, undertook in a small way the production of beet-root sugar at Northampton, Mass. He was attracted by the method of drying the roots that had lately been invented by Schutzenbach, both for the purpose of preserving them and for facilitating the extraction of sugar, but being unable to obtain from Schutzenbach any information concerning the details of the method unless he would purchase the exclusive right to use in the United States, and give security for payment in case success should be obtained in a model factory, Mr. Child operated the method with apparatus of his own device, by means of which he was able, with a temperature of 150° to 185° Fahr., to dry 800 pounds in twenty-four hours. The dried product was ground, treated with three times its weight of water, and subjected to pressure, giving, it was said, a liquid twice as rich in sugar as the ordinary juice of the beet. In his little work entitled 'The Culture of the Beet and the Manufacture of Beet Sugar,' Mr. Child informs us that the cost of culture in the Connecticut River Valley was, in 1838 to 1839, \$42 per acre, with an average yield of 13 to 15 tons; that the crop yielded 6 per cent. of sugar and 2½ per cent. of molasses, and the cost

* McMurtrie, *op. cit.*, p. 167.

of the sugar 11 cents per pound, pulp and manure not taken into account. But he does not mention the surface sown in beets nor the quantity worked up. From other sources, however, we learn that the quantity of sugar obtained was 1,300 pounds.

"The interest in the beet-sugar industry in the United States seems to have been quite dormant, or at least not sufficiently strong to manifest itself in active work, and its subsequent history, which, as before stated, was a rather checkered one, began in 1863 with the inauguration of the well-known enterprise at Chatsworth, Ill., by the Gennert Brothers, formerly of Braunschweig, Germany, and later of New York City, which, on account of the ill-chosen location as regards soil and climate, really the two principal conditions of successful culture, failed after a struggle of nearly six years. Bad management and lack of practical knowledge of the industry in the first few years, bad culture in 1868, deluging rains in 1869, and drought in 1870, in addition to the abundance of nitrates found to exist in the soils, appear to be the causes tending to the disastrous result. As a final struggle to maintain an existence the company removed the works to Freeport, in Stephenson County, of the same State, and though the saline character of the soil, which was a bane to the culture in the former locality, did not exist here, the efficient management of the able superintendent could not provide against the unfavorable climatic influences, and one year later the Germania Beet-Sugar Company finally succumbed, and its superintendent removed with some of the machinery of the late company to Black Hawk, Sauk County, Wis., to join with the co-operative enterprise that had been started there a year before. But the lessons of experience appear to have been no guide, for this attempt was made, like the previous ones, in a section not provided with the principal requirements for successful work.

"The crop of 1870 partially failed through drought. The machinery for the utilization of what there was arrived late, and the ponds upon which the company relied for water supply dried up before all the roots were worked for sugar, and a portion was left to be fed to cattle. Though additions were made to the works during the following year by means of machinery brought from Illinois and Fond du Lac, the result of 1871 does not seem to have been profitable, for since that time the enterprise has been so completely lost sight of that it is impossible to obtain any further information concerning it. The experiment at Fond du Lac, which, however, was not long continued, seems to have been the first to give unquestionably good results. It was started by two Germans, Messrs. Bonesteel and Otto, who organized a company with \$12,000 capital, and though compelled, with their limited means, to work on a small scale, their success was such during the two years of existence of the enterprise as to attract the attention of capitalists on both sides of our continent, and they received an offer from Philadelphia of funds to carry on the work where they had so successfully established

it, and another from San Francisco to put them in charge of the works of the Alvarado Sugar Company, which had just been organized with a capital of \$250,000, and, finding the latter offer the most tempting, they abandoned their works at Fond du Lac and migrated to the Pacific coast, where they managed to carry on the work with varying success until 1873, when it was reported that the company proposed removing to a more eligible locality. But it does not appear that this proposition was carried out, for what reason we are not informed; though Mr. Otto, who was then superintendent, and who, with his colleague in the Fond du Lac enterprise, Mr. Bonesteel, had become partners in this company, was shortly afterwards transferred to Soquel, in Santa Cruz County, where as late as 1876 the factory was reported as being in successful operation. The Alvarado Company struggled on until 1876, when drought having destroyed the crop so completely that there was no raw material for work in the factory in the ensuing winter, the company not having realized enough to enable them to carry over until the following season, failed financially, and permanently closed their operations.

"The Sacramento Valley Company was organized in 1869, and commenced extended operations in manufacture in 1870, and its existence was maintained until the close of 1875, when the machinery, which had cost \$160,000 in Germany, was offered for sale at \$45,000, and we have no information to the effect that it has been sold. Concerning the industry, a writer in the *Alta California*, during 1869, says:

"'Something new and unexpected has revealed itself. In Europe the beet attains its maximum of sugar in the latest period of growth before the frost sets in. Here it has lost half its sugar in the last six weeks—last of October. The beets taken from the same soil and milled in December by Wadsworth, superintendent, had the full complement of sugar.'

"The Soquel factory soon followed the fate of the others, but causes of its failure have not been assigned.

"The importance the manufacture attained in California is shown in the following statistics of beet sugar produced, published in 1874 by the State Agricultural Society:

	Pounds.
1870	500,000
1871	800,000
1872	1,125,000
1873	1,500,000

"But notwithstanding these figures, which are certainly flattering to the industry, there has not been a factory in operation in the State since 1876, and the capital invested in the manufacture, nearly \$1,000,000, has been a total loss, the causes of which may undoubtedly be traced to conditions determined in the Department during the present year by the study of European history and practices to be manifestly unfavorable and decidedly deleterious to the successful prosecution of the industry. We refer more particularly to the meteorological conditions

prevailing during the season of growth, which, as appears from the relations worked out, have a clearly defined influence for good or for evil, for success or failure, in the culture of the sugar-beet, and it is an interesting fact to note that at none of the localities where the experiments made have been attended with failure are the prevailing meteorological conditions found within the limits determined to be favorable to or governing the extension of successful culture.

“The experiments made up to this time received no aid or encouragement either from the State governments or from the General Government, with the exception of the provision that no machinery purchased abroad and imported for manufacture of sugar from the beets in this country should be subject to customs duty, and the limited assistance given by the Department of Agriculture in contributions of seed of the better varieties for experiment, and such information on the subject of the culture of the root and the manufacture of sugar as could be obtained by the means at hand; but this limited assistance was not of a character to produce any very marked effects.

“In 1870 to 1871 the States of New Jersey and Massachusetts made legislative provision exempting from taxation for ten years from date all capital and property engaged in the beet-sugar industry, but no practical results seem to have followed this provision. In New Jersey, however, Mr. Joseph Wharton, of Camden, has during the past three years devoted a portion of his estate at Batsto to some very intelligent experiments in the culture, which, as regards the quantity of the product, has given unsatisfactory results, and only tend to show that the climatic conditions of the section, possibly combined with the light character of the soil, are not such as to render the permanent establishment of the industry in that locality possible.

“In 1876 the Canadian Government offered a premium of 1 cent per pound for all sugar manufactured from the beet-root, the total sum paid to any one individual company or corporation not to exceed, however, \$7,000 per annum.

“This premium stimulated the culture of the crop and the establishment of factories, which have continued in active and profitable operation.

“The State of Maine followed the worthy example of its near neighbor and in the same substantial terms; the Forest City Sugar Refinery at Portland hastened to take advantage of the premium offered, and the experiment on a small scale in the manufacture by the company, as had been the culture by the farmers in 1878, resulted in such brilliant success that the company have this year so enlarged the capacity of their works as to enable them to work 150 tons of roots per day and have secured from the farmers a crop from 1,250 acres of land. Their success has also animated the people of Massachusetts, who have organized a company for work at the locality of Child’s experiment of 1838-’39, at Northampton, Mass.

"In 1876 and 1877 Delaware appropriated \$300, and in 1878-79 \$1,500 to be expended in premiums, etc., to stimulate the culture, and the result has been the establishment of the Delaware Beet Sugar Company at Wilmington.

"In California also interest in the industry has again been awakened through the instrumentality of Mr. Th. Gennert, whose worthy enthusiasm led to the establishment of the enterprise in Canada and in Maine. The work is to be renewed at the factory of the former Alvarado Company, and Gennert's scheme for drying the beets for preservation and transportation, which was attended with such disastrous results at Chatsworth and in Maine, is to be tried once more. It is understood that Mr. Gennert is now interested in the Alvarado Company and expects to carry out his plan for drying the beet-roots, and, thus diminishing the cost of transportation, increase the profits of manufacture, in which we hope he may be successful. The culture of the beet has also been undertaken in Santa Clara County, where it is proposed to supply deficient moisture by irrigation, and to dry in open sunlight the roots, of which it is declared two crops can be produced in one year. Without wishing to discourage the enterprise in any way, we may venture to express the hope that the promoters are acquainted with the experience of the growers of the south of France and Italy, as described by Gustave Heuzé in his work '*Les Plantes Fourragères*,' page 9, where he says:

"The beet succeeds well in the cold climates of Europe. It will grow in southern countries, but it suffers there from heat or drought; its root remain small, green, and contains little sugar. An attempt was made to hasten its growth in Lombardy by frequent irrigation during the summer, but irrigation was fatal to it, and growers were forced to adopt other means to assure success."

"We would also call attention to the fact that in Algeria, where the enterprise of preparing beets for preservation and transportation by drying in open sunlight, the success, if any was obtained, has not appeared worthy of record.

"Besides the arrangements that have been made for the production of sugar from the beet at the different places mentioned active interest has been awakened elsewhere, particularly at Baltimore, Md., Chester, Pa., and at various localities in New York, but these movements have not yet assumed definite shape."

THE EARLY HISTORY OF BEET-SUGAR INDUSTRY AT ALVARADO.*

"No history of Alameda County would be complete without some mention of the rise and progress of this promising industry, which, so far as California and the Pacific coast are concerned, had its origin at Alvarado—its failure and its final success.

"The first attempt to manufacture beet-root sugar in California was made at Alvarado in 1869. Messrs. Bonesteel, Otto & Co., who were engaged in a small way in the business at Fond du Lac, Wis., opened

* Bull. No. 5, Chem. Div. U. S. Department of Agriculture, p. 89.

a correspondence upon the subject with General C. I. Hutchinson, E. H. Dyer, and others on this coast. The matter was pushed with zeal, and the 'California Beet Sugar Company' was organized with a capital stock of \$250,000. The stockholders were: General C. I. Hutchinson, Flint, Bixby & Co., T. G. Phelps, E. H. Dyer, E. R. Carpentier, E. Dyer, W. B. Carr, W. T. Garratt, and E. G. Rollins, all well-known capitalists and enterprising business men of California; and A. D. Bonesteel, A. Otto, and Ewald Klinean, of Wisconsin. The eastern parties, who were to assume the technical management of the business, arrived in California in the spring of 1870, and arrangements were immediately made for the erection of a factory. The location chosen was the farm of E. H. Dyer, at Alvarado. The work was pushed with such energy that the building was completed by the contractor, B. F. Ingalls, esq., in November of the same year.

"It is unnecessary to follow minutely the history of this company. It is sufficient to say that, after running four years at Alvarado, through the incompetency of the technical managers, it proved a financial failure. Messrs. Bonesteel & Otto contended that the location at Alvarado, not being a suitable place for the business, was the cause of the failure, and succeeded, by their plausible representations, in organizing a new company, which purchased the Alvarado machinery and removed it to Soquel, Santa Cruz County, where, after operating a few years, subjecting its stockholders to a heavy annual loss, the enterprise was abandoned.

"E. H. Dyer, who had bought the buildings and a portion of the land owned by the old company at Alvarado, still had faith in the business, believing that with good management it could be made to pay at that place. He found it very difficult, however, in the face of so many failures, to induce capitalists to invest a sufficient amount to give the business another trial, and it was not until 1879 that the Standard Sugar Manufacturing Company was incorporated. The company consisted of A. E. Davis, O. F. Giffin, E. H. Dyer, Prescott, Scott & Co., J. P. Dyer, and Robert N. Graves, with a capital of \$100,000. It was soon ascertained that more capital was needed, and the company re-incorporated under the name of the Standard Sugar Refinery, with a capital stock of \$200,000. The officers are: O. F. Giffin, president; J. P. Dyer, vice-president; E. H. Dyer, general superintendent; W. F. Ingalls, secretary; trustees, O. F. Giffin, R. N. Graves, J. P. Dyer, G. H. Waggoner, and E. H. Dyer. This company has made a success of the business from the start. It earned 33 per cent. on the capital invested the last or third campaign, and is now just commencing on its fourth campaign with very flattering prospects. The success of this important home industry is greatly due to the general management of Mr. Dyer, who owns one-fourth of the stock, and who, profiting by former experience, is able to avoid many mistakes which have caused the failures of other establishments of the kind. The present factory has been

enlarged and improved until it now has a capacity of about 100 tons per day; employs at the factory 125 men, to say nothing of the great amount of labor necessary to produce the beets, harvest and haul them to the factory. One, to obtain an adequate idea of the business of this company and the great good it is doing in the way of using the products of the farmers and keeping employed so many of our people, should see the works in operation during the months of September, October, and November, when beets are being received.

"There are frequently lines of teams, all heavily laden with beets, from a quarter to sometimes half a mile in length, pushing along in line to reach the company's scales and deliver their loads. It is a scene of great activity. From fifteen to twenty thousand tons of beets are used each campaign, which require for their production ten to fifteen hundred acres of land. The company disburses among its workmen and the farmers nearly \$150,000 a year for labor and material used; all produced in Alameda County. They have turned out each campaign one and a half million pounds of pure white sugar. No low grades or yellow sugars are put on the market by them."

BEET-SUGAR FACTORIES AT CHATSWORTH AND OTHER PLACES.

In regard to these factories Prof. W. A. Henry writes as follows*: "The history of attempts to manufacture sugar from the beet in America is one of almost continuous failure. In 1838 David Lee-Child manufactured sugar in Massachusetts at 13 cents per pound, but a small quantity being made. In 1863 the Gennert Brothers, from Germany, built a factory at Chatsworth, Ill., in what is said to have been an unfortunate location, as the soil there was not suitable for beet-growing. Bad culture, wet seasons, drought and a soil too full of mineral matter brought disaster, and about 1870 the enterprise collapsed. From Chatsworth the machinery was moved to Freeport, where the Germania Sugar Company after a brief existence dissolved, and the machinery was again moved, this time to Black Hawk, Sauk County, Wis., where failure was again met. At Fond du Lac, in this State, Messrs. Bonesteel & Otto organized a company with \$12,000 capital, and struggled during two years, making, it is reported, considerable sugar. Their success could not have been very marked, for they accepted an offer to join a company at Alvarado, Cal., which started out with \$250,000 capital. The Alvarado Company also went to the wall, as did two or three other California concerns. A factory was also started in Maine, and another in Delaware, but these met the universal fate. The Alvarado factory was re-organized, and for several years made considerable quantities of sugar, the product some years reaching two or three million pounds; but owing to the antiquated machinery and limited capacity the investors received little or no dividends.

* Western Farmer, Madison, Wis., March 29, 1890.

"The beet-sugar industry in America may be said to have closed its first era a couple of years ago, and the results, from a financial standpoint, may be summed up in one phrase, 'complete failure.'

"We are now, I trust, entering the second era, which will doubtless be more successful than the first, but its history lies in the future, and its making is with the people.

"The second era of the industry may be said to have begun with the reorganization of the Alvarado factory upon a sound basis last year, and the building of the Spreckels' factory at Watsonville, Cal. These enterprises are in the hands of men who will succeed if success is possible."

For further particulars respecting the Chatsworth factory I wrote to Mr. John P. Reynolds, of Chicago, and received the following reply:

CHICAGO, *December 9, 1889.*

DEAR SIR: Your favor of 5th instant, requesting written papers or observations I may wish to make upon the subject of beet-sugar manufacture in this country, is received.

Twenty-odd years ago, at Chatsworth, Ill., some few of us made about a \$300,000 failure in attempting to establish that manufacture. The factory was well equipped, as we understood it. The lands, say 1,000 acres, were first-class high, rolling prairie. Compared with the present the processes of manufacture and machinery were doubtless imperfect, but they were supposed to be the best approved in Germany at that time. After we gave it up the business was carried to Freeport, Ill., and started up by three gentlemen of large wealth, on good old lands, by the side of a town of 15,000 people. It failed again.

Without going into details further, I must say that I have given up hope for the early success of beet-sugar industry in this country, because I believe the essential conditions are not to be found here at present. These conditions relate to the production of the beets. The manufacturer must grow his own beets, or have them grown in the vicinity by others. He can not command the necessary labor to grow them himself, except at a cost that the results will not justify. There is no crop within the whole range of agriculture more difficult to produce than a crop of beets suitable for the manufacture of sugar. An army of women and children (being the cheapest labor) is required imperatively at special times, and I know of no community where this army can certainly be had when needed and at a fair cost.

If others grow the beets, contracts must be made in advance for the entire crop of each, a certain number of acres to be cultivated. The product per acre is variable and uncertain in both quantity and quality. There may be a superabundance for the capacity of the factory, or there may be a failure of the crop almost entirely. As to price per ton the advantage is always on the side of the farmer. The manufacturer must pay what the farmer may demand, or quit the business and lose his plant. The farmer can use his land for other crops; the factory will make only beet-sugar.

With irrigated lands and slave labor, or its equivalent, I can understand that sugar from beets can be produced profitably in this country.

I would like to believe this industry will soon demonstrate the error of my present convictions thus briefly stated, and certainly the effort to make it successful is worthy any man's ambition.

Yours, truly,

JOHN P. REYNOLDS.

Mr. H. W. WILEY,

Chemist, Department of Agriculture, Washington, D. C.

STATISTICAL.

THE GERMAN CAMPAIGN OF 1888-'89.

During this campaign the new law levying a part of the tax on the beets and a part on the sugar produced came into operation for the first time. The object of this law is to diminish the bounty paid on exports. By the new law the tax on the beets has been reduced to .80 marks per 100 kilograms, instead of 1.7 marks as by the former law. On the other hand, sugars entering consumption pay 12 marks per 100 kilograms, whereas before they paid nothing when made from native beets.

The quality of the beet root harvested in 1888-'89 was much inferior to that of the preceding year. This inferiority was caused by a late wet spring and an excess of rain in June and July. While the yield of beets was larger, the saccharine strength was lower than had been known before in many years. The yield of sugar was also diminished by early frosts, by which many beets were frozen before they could be properly harvested and siloed. The juice of such beets was cooked with extreme difficulty, being difficult to filter and granulate. Many factories by reason of these difficulties were led to refuse to accept beets that had been frozen.

The following table, according to M. Licht, gives the actual production of sugar in Germany in metric quintals* and the percentage of yield on the weight of the beet from 1871 to 1889:

[Sugar, April, 1890, p. 496.]

Year.	Real production.	Actual yield.	Year.	Real production.	Actual yield.
		<i>Per ct.</i>			<i>Per ct.</i>
1871-'72	1,864,419	8.28	1880-'81	5,730,214	9.06
1872-'73	2,625,511	8.25	1881-'82	6,222,885	9.92
1873-'74	2,910,407	8.25	1882-'83	8,489,226	9.71
1874-'75	2,564,124	9.30	1883-'84	9,606,093	10.77
1875-'76	3,580,482	8.60	1884-'85	11,467,303	11.02
1876-'77	2,909,227	8.19	1885-'86	8,381,049	11.85
1877-'78	3,805,091	9.30	1886-'87	10,237,339	12.32
1878-'79	4,301,551	9.35	1887-'88	9,591,184	13.77
1879-'80	4,154,152	8.64	1888-'89	9,904,776	12.55

* Divide by 10 to get tons of 2,200 pounds each.

COMPARATIVE DEVELOPMENT OF THE CANE AND BEET SUGAR INDUSTRY.*

The following table expresses in tons of 2,200 pounds the relative amounts of cane and beet sugar made in the world during the past seven years:

Year.	Beet.	Cane.	Total.
1883-'84.....	2,361,000	2,323,000	2,684,000
1884-'85.....	2,546,000	2,351,000	4,897,000
1885-'86.....	2,220,000	2,340,000	4,560,000
1886-'87.....	2,730,000	2,345,000	5,075,000
1887-'88.....	2,452,000	2,470,000	4,922,000
1888-'89.....	2,765,000	2,280,000	5,045,000
1889-'90.....	3,500,000	2,278,000	5,778,000

It is seen from the above table that the production of cane-sugar has remained stationary or even diminished during the last septennial period while the production of beet-sugar has experienced an enormous progress.

Willet and Gray (Louisiana Planter and Sugar Manufacturer, April 5, 1890), give the following estimate of the total sugar crop of the world, in tons, for the last five years:

Country.	1889-'90.	1888-'89.	1887-'88.	1886-'87.	1885-'86.
Cuba.....	600,000	530,000	610,000	608,900	705,400
Porto Rico.....	70,000	55,000	50,000	86,000	64,000
Trinidad.....	60,000	60,000	60,000	69,000	49,200
Barbadoes.....	60,000	50,000	60,000	65,000	44,000
Jamaica.....	30,000	28,000	30,000	21,000	17,000
Antigua and St. Kitt's.....	28,000	25,000	26,000	25,000	25,000
Martinique.....	40,000	38,000	39,000	41,000	33,000
Guadeloupe.....	50,000	45,000	50,000	55,000	37,000
Demerara.....	125,000	108,000	110,000	135,000	111,800
Reunion.....	30,000	25,000	32,000	32,000	35,000
Mauritius.....	125,000	132,000	120,000	101,800	114,200
Java.....	310,000	364,000	396,000	363,950	365,950
British India.....	60,000	60,000	55,000	50,000	50,000
Brazil.....	150,000	220,000	320,000	260,000	186,000
Manila, Cebu, and Iloilo.....	180,000	210,000	174,000	180,000	186,000
Louisiana.....	125,000	145,000	158,000	80,900	127,900
Peru.....	30,000	30,000	30,000	26,000	27,000
Egypt.....	35,000	35,000	35,000	50,000	65,000
Sandwich Islands.....	120,000	120,000	100,000	95,000	96,500
Total of cane.....	2,228,000	2,254,000	2,465,000	2,345,550	2,339,950
Total of beet.....	3,550,000	2,753,844	2,451,950	2,730,206	2,219,973
Cane and beet.....	5,778,000	5,007,844	4,916,950	5,075,756	4,559,923

La Sucrerie Belge of March 15, 1890, page 372, gives the following estimate of the total production of beet sugar in Europe during the past four years, in tons of 2,200 pounds:

Country.	1889-'90.	1888-'89.	1887-'88.	1886-'87.
Germany.....	1,220,000	978,000	953,400	1,015,600
Austria.....	730,000	514,000	400,000	550,000
France.....	750,000	460,000	420,000	497,000
Russia.....	445,000	503,000	430,000	455,000
Belgium.....	172,000	96,000	93,000	91,000
Holland.....	55,000	35,000	37,000	36,000
Denmark.....	20,000	19,000	21,000	18,300
Other countries.....	25,000	21,000	14,000	13,000
Total.....	3,417,000	2,626,000	2,368,400	2,675,900

* La Sucrerie Indigene, March 11, 1890, p. 233.

STATISTICS OF THE PRODUCTION OF CANE AND BEET SUGAR.

Licht, of Magdeburg, in his last report (*Journal des Fabricants de Sucre*, March 26, 1890), gives the following figures for the production of beet sugar in Europe for the last three campaigns :

[In tons of 2,200 pounds.]

Country.	1887-'88.	1888-'89.	1889-'90.
Germany	956, 166	990, 604	1, 260, 000
Austria	428, 616	523, 242	750, 000
France	392, 821	466, 767	775, 000
Russia	441, 342	525, 387	475, 000
Belgium	140, 742	145, 804	200, 000
Holland	39, 280	46, 040	60, 000
Other countries	79, 980	87, 000	80, 000
Total.....	2, 481, 950	2, 785, 844	3, 600, 000

PRODUCTION IN RUSSIA.*

During the campaign of 1889-'90 two hundred and twenty-five factories were operated in Russia. The harvest of beets amounted to 17,370 kilograms per hectare against 18,680 kilograms per hectare the preceding year. The beets also were much poorer in quality during the last year, the mean polarization being 12.93 per cent. of sugar against 14.20 per cent. the preceding year.

THE PRODUCTION OF CANE SUGAR IN JAVA.*

During the season of 1889 there were operated in Java one hundred and seventy-eight factories, producing 5,440,397 piculs of sugar.

PRODUCTION OF SEED.

There is, perhaps, no other agricultural crop which has illustrated in so marked a manner the importance of seed selection as the sugar beet. By the careful selection of those variations in the original beet which seemed most favorable to the production of sugar, and the careful selection of beets in the production of seed during the succeeding year, and by judicious and scientific fertilizing for the purpose of increasing the sugar content, there has been a great evolution in the sugar-producing power of the beet which has placed it at the head of the sugar-producing plants of the world.

The influence of the quality of the seed, according to Vilmorin, is absolutely predominant from the point of view of the results obtained in the culture of the sugar beet. The numerous experiments of scientific investigators has shown that remark to be true. In France the firm of Vilmorin-Andrieux & Co. has paid special attention to the improvement

* *Journal des Fabricants de Sucre*, March 19, 1890.

of the standard varieties of the sugar beet by the method above mentioned. They have endeavored to produce different varieties of beets of which each one would have all the possible advantages in the different economical and culture experiments to which manufacturers and farmers will submit them.

It is true, without doubt, that the same variety of beet could not be the most advantageous in every case, and that, according to the results to be obtained, it might be an advantage in one place to cultivate a variety extremely rich and in another place one, which, while still rich in sugar, would also produce a heavy yield in pounds. To these different needs different varieties of beets respond. In one case the pure white variety, in another the white variety with green neck or the rose variety with rose neck, or the Vilmorin Improved, a variety which is suitable everywhere and particularly in those countries where the duty on beet-sugar is laid directly on the beet. Since the introduction of the new law in France, in 1884, levying the tax upon the actual weight of beet produced, the White Improved Vilmorin beet has recommended itself by its exceptional richness, its great purity, and the ease with which it can be preserved. But in order to meet all the conditions necessary to the greatest success it is necessary to find out by experiment that variety of beet, which, in any given locality, fulfills most of the conditions required to produce a high yield of sugar with a minimum cost and one which will be equally profitable to the farmer and manufacturer.

At the present time, it is necessary in this country to go abroad for beet seed of the highest character. Up to the present time the sugar-beet seed which has been grown in this country has been produced without especial reference to the conditions necessary to maintain the beet at a high standard and to improve it as is done in foreign countries. In other words, the sugar-beet seed which one will obtain from American dealers, if it should be that which is grown at home, does not come with the pedigree of the beet, in regard to content of sugar and purity of juice, nor with that assurance of care in cultivation which the professional producers of beet seed in foreign countries bestow upon their work. There is no reason, however, to suppose that it is impracticable to produce beet seed in this country of as high a grade and of as pure a quality as that which can be obtained in other countries. The method of doing this will be briefly indicated.

In growing the beets the greatest care should be taken to secure all the conditions necessary to produce a beet of maximum richness in sugar, coupled with a yield per acre of fair proportions. This can be done by attending to the directions for culture to be given, combined with judicious application of those fertilizers which will tend to increase the sugar content of the beet without unduly increasing its size. The fertilizers which are most suitable for this purpose are carbonate of lime, when it is not present in sufficient quantities in the soil, a small quantity of magnesia, and larger quantities of phosphoric acid with varying pro-

portions of potash and nitrogen, according to the character of the soil in which the beets are grown. No certain rule can be given for the application of fertilizers until the conditions of the season and the character of the soil in each particular locality have been carefully studied experimentally. For this reason, it is certain that in this country, as in others, the business of producing beet seed will be one entirely distinct from that of raising beets for manufacture or for the manufacturing thereof. It is this business which will require not only the highest scientific agriculture but the most careful agronomic skill.

SELECTION OF "MOTHERS."

The beets which are to be used for producing the seed should be selected on account of the possession of those properties which are most suitable to secure the highest results in the production of sugar. In the first place, all beets of irregular or unwieldy shape should be rejected; those selected should be of uniformly even texture, smooth outline, and symmetrical shape.

The sugar content of these beets should be determined by the analysis of others grown in the same plot and of the same seed, and thus obtain the average content of sugar for the whole lot. Only that class of beets showing the highest content of sugar combined with the qualities given above, and the greatest purity of juice, should be preserved. In many cases the beets themselves, which are to be used for propagation of seed, are subjected to analysis by the removal of a cylindrical section by an instrument provided for that purpose and the analysis of this section. In this way the actual sugar content of the beet which produces the seed can be obtained. It is said that good results have also been secured by replacing the portion of the beet removed by sugar at the time of planting, which will afford an additional food product for the earlier growth of the beet in its second year.

Another method of selecting the beets, which has been widely employed, is that of determining their density. A solution of some substance is made in water, such as salt or sugar, of such a density as to permit beets of inferior quality to float on the surface and those of superior quality to sink. These heavier beets, other things being equal, contain larger quantities of sugar and are more suitable for the production of seed. The beets, of course, which are to be used for the production of seed must be very carefully harvested so as not to be bruised, leaving the roots as much as possible uninjured, and they must be carefully preserved in silos over the winter until the time for transplanting in the spring. The transplanting and the successful cultivation of the beets need no detailed description.

The character of the beet is also sometimes determined by removing a small portion, as indicated above, for polarization, expressing the juice and determining its specific gravity by weighing in the juice a silver button of known weight.

The absolute necessity of securing a few beets of the highest sugar co-efficient and purity for the purpose of producing a crop of seed in third, fourth, or fifth year, according to the number selected, has in the last few years been recognized to a degree unknown before. At first it was the custom to select the beets, by some of the methods mentioned above, in large numbers sufficient to grow in the second year seed for the market. A much more rational method, however, and one which secures higher results, consists in a more careful selection of the mother beets for the purpose, not of producing seed for the market in the second year, but only for the purpose of producing for securing an additional crop of beets in the third year which in the fourth year will produce seed for the market. The methods employed by different seedsmen vary somewhat, but the principle in all cases is the same. The general method may be indicated by that pursued by Dippe in Quedlinburg:*

First year.—Seed planting for mother beets, from seed which came from the highest polarizing beets of different varieties, which have, of course, been kept separate. The planting is in rows 18 inches apart, and the plants are cut away in the rows so as to stand 10 or 12 inches apart. At the time of harvesting the beets are selected out according to form, growth, and leaf formation, as these best approximate the characteristics of the parent variety.

Second year.—In March and April these selected beets are examined in the laboratory† in the following manner:

At a certain point which it is presumed will give an average of the entire beet, a cylindrical piece is cut out, subjected to strong pressure in a juice-press, which will give, for example, from 17 grams of beet 10 grams of juice, of which 5 cubic centimeters are diluted with lead acetate and water to 25 cubic centimeters, filtered and polarized. For the different varieties minimum limits are established, and the beets are arranged in three classes according to their polarization:

First, beets which go below the limit and are thrown out; second, beets which are above the limit, and fairly good for seed purposes, and, third, beets which show an extra high figure.

These extra good beets are now examined still further, two more cylinders taken out, and the sugar estimated by the extraction method. From this result and the estimation of the sugar in the juice the (apparent) content of juice is calculated. Those beets which do not reach a standard, established for each variety (between 92 and 94), are thrown out, while those that attain it are the chosen "mother beets" of the crop, which are to perpetuate the variety, and which furnish the seed for each new succession, as mentioned in the first paragraph.

In this second year are planted out all the beets saved, the extra and medium as well; the former furnish seed for extra mother beets, which

* Stammer, pp. 200, *et seq.*, Lehrbuch der Zucker Fabrication.

† This is not done until spring in order that only well-preserved beets may be chosen.

are used as indicated for the normal-sized mother beets which furnish seed for a new succession, while the latter are to produce a generation of dwarfs, the seed from both being harvested this year.

Third year.—The seed from the medium and extra mother beets is planted, and the latter produce the mother beets for future breeding purposes, as indicated, but the plants from the former seed, which was planted a little later than would be the case for beets ordinarily, and in soil fertilized with ammoniacal superphosphate and also some guano, in rows 12 inches apart, are cut out to about every 3 to 5 inches. The small beets are very carefully preserved under a thick covering of earth. In the spring of the

Fourth year.—They are uncovered and planted at about 26 to 24 inches apart. The seed from these when harvested in the fall is ready for the market, so that it has taken five years to attain this end.

In the establishment of Branne, in Biendorf, the procedure is similar, but the beets are selected by their specific gravity in the field. A woman sits at a table and cuts from each beet a very small piece and throws it into a solution of salt of known density (for example, with the Klein Wanzleben, 16° Brix). If the piece of beet floats, the corresponding beet is thrown away, but if it sinks the beet is reserved for further investigation in the laboratory. The beets chosen in this way are submitted to further selection by the examination of the juice from a cylinder.

In a somewhat different way, but still by means of the examination of individual beets, is the culture of the Klein Wanzleben variety carried on by Rabbethge, in Klein Wanzleben, whose object is not so much to furnish establishments with all the seed they require for planting, but rather with seed for the production of mother beets, and their own seed from these. The fact that Klein Wanzleben has never yet harvested more than 3 tons of seed in a season indicates the character of the work, which is much to be commended.

The seeds are always taken from mother beets of considerable weight, never from small or dwarf beets, and the aim is not so much to produce individual beets of exceptionally high sugar content, but large beets as well; that is, beets which give the highest yield of sugar from a given amount of land. These roots, which are chosen from a field of the best (Elite) beets, and which possess most distinctly the characteristics of the variety, are weighed and their juice polarized, and this operation is continued until 20,000 beets are chosen which fulfill the requirements as to weight and sugar content.

These 20,000 best mother beets are sufficient to furnish the planting of a hectare ($2\frac{1}{2}$ acres), and from them are obtained 40 to 60 hundred weight of the best (Elite) seed, and this gives the following year 60 to 100 hectares of the best (Elite) beets, or 5,000,000 to 7,000,000 plants. From these are finally chosen the 1,500,000 seed-bearers which furnish the planting of 100 hectares and the seed for sale and for the perpetuation of the breed.

An entirely different method of selection is what is known as "family" breeding. Hundreds of specially-selected beets, excellent in every way, are planted out separately. The seed of each is gathered and planted separately. If among the beets thus obtained any are found that excel the mother beet in every respect, and this improvement endures through several generations, these are incorporated with the other mother beets and used for breeding. As examples of weight and polarization of the selected beets the following figures for the highest and lowest weights are given, representing the best mother beets of the years 1883 and 1884:

Weight.	Sucrose in juice.	Weight.	Sucrose in juice.
<i>Grams.</i>	<i>Per cent.</i>	<i>Grams.</i>	<i>Per cent.</i>
1,550	11.24	600	15.11
1,450	13.68	600	16.28
1,250	14.29	600	16.28
1,500	15.87	400	16.13
1,450	14.60	550	15.62
1,700	11.76	400	16.83
1,860	14.86	550	16.88
2,100	14.35	400	16.63
1,900	14.60	600	15.63
600	16.13		

Among 200 beets were found only 11 with a weight of less than 500 grams; 12 with a weight of 500 to 600 grams; 29 with a weight of 600 to 700 grams; 21 with a weight of 700 to 800 grams; and finally 127, or 63 per cent., with a weight of over 800 and up to as high as 2,100 grams.

The beets between 700 and 1,000 grams are of nearly identical sugar content, a peculiarity of the Klein Wanzleben variety.

The established normal weight varies, according to the season, between 600 and 900 grams; in the year 1883 it was 897 grams, corresponding to the average of the beets from a field.

A still different method is followed by v. Proskowetz (Kwassiz). The beets from which selections are to be made are placed in a solution of salt showing 17.5° Brix, and those which float are used as fodder; those which sink are analyzed for sugar content by the alcohol extraction method, for which purpose a small quantity, half the normal weight, is cut out with a rasp and polarized in a 400-millimeter tube. Beets which give at least 19 per cent. of the beet in sucrose form the first class; those showing 18 to 18.9, inclusive, the second, and those from 16 to 18 the third. Beets under 16 per cent. are used for fodder.

PRESERVATION OF BEET-SEED.

It is recommended by D'Haussey (Jour. des Fabricants de Sucre, April 16, 1890) to place in each bag 100 pounds of seed, 1 pound of powdered sulphur, and 1 ounce of carbolic acid, and mix thoroughly.

These substances preserve the seed completely from every kind of insect from the time it is planted until the root is developed. The outside of the bag should be coated with tar, and the seed kept therein for two weeks before planting.

VARIETIES OF BEETS GROWN IN FRANCE.*

THEIR CHARACTERS, MODE OF SELECTING, ETC.

"The importance of the variety or race of the beet to be grown for sugar can not be questioned. A beet giving a large cultural yield rich in sugar involves no more cost to the grower in its production than one giving a small yield and low saccharine value. It is therefore useful to choose those which will give the greatest returns and be at the same time the most satisfactory in every way to the grower who must produce them and to the manufacturer who must extract the sugar.

"For the latter it is admitted that the raw material—the juice of which contains the smallest percentage of mineral and organic impurities, other things being equal—will give a larger yield of sugar than juices in which these constituents exist in larger proportions, and it is well known and generally understood that these favorable conditions are found in roots of moderate size more frequently than in large ones. Thus Briem† says 'The size of the beet is in the inverse ratio of its content of sugar and salts; the content of water increases with the size and weight of the beet'; and Champion and Pellet state‡ that beets of good quality generally have an average weight of 700 to 800 grams ($1\frac{1}{2}$ to $1\frac{3}{4}$ pounds), and this size seems to be generally adopted as the most favorable by the best authorities on beet culture in France and by the manufacturers almost unanimously.

"The rule that the smaller the beet the richer in sugar appears to find illustration if not complete confirmation in the results of examination of the beets submitted by Professor Deherain§ to experiment at the college farm at Grignon and produced from seed furnished by Vilmorin-Andrieux & Co.

Number.	Improved exposition beets.		Improved beets No. 848.		Pink-top beets, Verrières.		Pink top No. 34.	
	Weight of beet.	Sugar in juice.	Weight.	Sugar in juice.	Weight.	Sugar in juice.	Weight.	Sugar in juice.
	Grams.	Per cent.	Grams.	Per cent.	Grams.	Per cent.	Grams.	Per cent.
1.....	395	18.1	282	20.0	980	13.10	530	13.75
2.....	365	16.7	330	20.0	460	12.05	622	13.10
3.....	720	16.4	660	18.8	630	11.30	837	12.50
4.....	600	15.6	450	18.7	627	10.00	1,115	11.25
5.....	620	15.0	385	18.4	890	9.84	1,040	10.60
6.....	740	13.9	335	18.4	1,150	9.20		
7.....	1,130	13.4	560	17.7				
8.....	850	13.2	580	16.9				
Averages..	677	15.5	447	18.6	789	10.91	828	12.24

"The form of the beet seems also to be an important feature in the consideration of the proportion of sugar to be obtained, and Champion

* McMurtrie, *op. cit.* pp. 71 *et. seq.*

† Journal des Fabricants de Sucre, October 23, 1878.

‡ La Betterave à Sucre, p. 98.

§ Annales Agronomiques.

and Pellet further state,* concerning beets of good quality, "their form is elongated and tapering." This admits of more thorough penetration of the root in the soil, more complete contact with the nutritive elements, moisture, etc., insures the plant against variations of existing conditions, and consequently a healthier state, from which must naturally follow a better quality.

"Corenwinder and Contamine † find that there is a relation between the size of the leaves and the richness of the roots; that roots which bear leaves of broad surface are generally more rich in sugar than those having small leaves upon a contracted top, and these facts are confirmed by analyses of subjects taken from the same field. At the same time Deherain concludes from his researches ‡ that the weight of leaves of small beets is relatively greater than is produced by larger ones. The relations found are as follows:

Variety of beets.	Weight of leaves.	Weight of roots.	Sugar in 100 of juice.
	<i>Grams.</i>	<i>Grams.</i>	
Pink top O.....	281	1,393	9.94
Pink top Enterré.....	375	984	10.18
Improved 1,093.....	531	863	14.42
Improved 927.....	531	787	14.78

In connection with this relation between the size and richness of the sugar-beet and the number and weight of leaves they bear Champion and Pellet§ give following figures.

Variety of beets.	Leaves per 100 of roots.	Sugar in beet.
	<i>Pounds.</i>	<i>Per cent.</i>
Improved Vilmorin.....	56	14.5
Simon Legrand (choice).....	33	13.3
Ordinary of sugar factories.....	20	11.8

Beets produced in special cultures.

Variety.	Roots.	Leaves.	Sugar.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per cent.</i>
Ordinary seed, special culture.....	100	52	13.2
Ordinary seed, ordinary culture.....	100	28	11.8

"Other tests gave—

Sugar in roots.	Weight of leaves per 100 pounds.	Sugar in roots.	Weight of leaves per 100 pounds.	Sugar in roots.	Weight of leaves per 100 pounds.
<i>Per cent.</i>		<i>Per cent.</i>		<i>Per cent.</i>	
15.4	58	14.7	62	13.5	36
15.2	63	13.1	31	12.4	25
14.1	52	13.8	26	11.8	26

* La Betterave à Sucre.

† *Ib.*, t. III, 98

‡ Annales Agronomiques, t. IV, 380.

§ La Betterave à Sucre.

"These are the principal external characteristics which seem to have an influence upon the composition and value of the beet, and for the description of the varieties finding greater favor in France and most extensively grown we shall quote from the writing of Mons. H. Vilmorin :

"It is generally admitted that the saccharine richness of beets is inversely proportional to their volume. Taken in a general way this proposition expresses a truth, but it is certain that selection judiciously applied may cause a variation of this relation, and enrich a given race of beets without diminishing either the volume or the yield. It is in modifications of this kind that we should seek the practical improvement of the beet, and the end proposed is to create, at different degrees of the scale, races of beets uniting with a given yield the maximum saccharine richness compatible with that yield.

"The search for a beet which shows at the same time a maximum of product and a maximum of richness is a chimera, and the sooner its pursuit is relinquished the more will disappointment and useless endeavor be avoided. In fact, high saccharine richness is necessarily allied to a great abundance of leaves and rootlets, and beets rich in rootlets and leaves can not become voluminous without becoming deformed and losing the external qualities of regularity and cleanliness which are in a great measure indispensable to a good race of sugar-beets.

"Starting out, therefore, with the idea that the different circumstances in which the manufacturer or the grower finds himself placed demand different beets, let us examine the really known varieties and what they may become under the influence of skillfully applied selection.



FIG. 1.—White Silesian Beet.

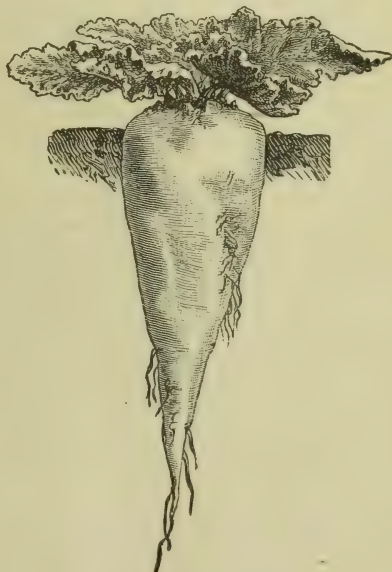


FIG. 2.—Imperial Beet.

"The White Silesian sugar-beet (Fig. 1), origin and point of departure of all the other varieties, is still preferred above all in a large part of Europe. It is a race of medium size, almost entirely buried with white skin, slightly wrinkled, leaves rather spreading than erect. It is rich in sugar, generally containing 12 to 14 per cent. Its yield in good conditions is about 20 tons per acre. It is perfectly adapted to close

culture, and does not require very deep soils. Cultivated in France for some years, it has increased in volume, and has come to yield easily 22 to 23 tons per acre. Now that there is a tendency to return to beets rich in sugar, the *acclimated white German beet* is one of the varieties most recommended.

"Of this there exist several sub-varieties, obtained by selection. We cite among the most distinct the *Magdeburg*, rather small, but long and very regular; the *Breslau*, shorter and more swollen; the *Imperial* beet (Fig. 2), obtained by Knauer, which is long, regularly tapering, having the form of a carrot, foliage light-colored, curly, and

approaching the ground; the *Electoral*, of the same origin, more (*gonflée*) swollen, larger, and more productive, but slightly less rich than the *Imperial*.

"The *green-top* sugar-beet, a French race (Fig. 3), is in much less favor to-day than it was fifteen years ago. It is, however, an excellent race, larger, better formed, and smoother than the Silesian beet. The top, which protrudes from the earth a few centimeters (a couple of inches) only, is colored green; the root is long, smooth, and white. This variety may give as high as 25 tons per acre, containing from 11 to 14 per cent. of sugar. Manufacturers who have continued to cultivate it have had reason to be satisfied with it. We have known its yield in sugar to be as high as 3.69 tons of 2,000 pounds per acre.

"The French *pink top* beet (Fig. 4) is that which has been most generally grown for years. The favor accorded it is justified by a collection of

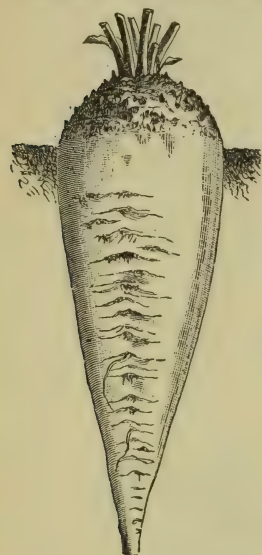


FIG. 3.—Green-top Beet.

qualities which seem to make the race the most advantageous of all, in the ordinary conditions of the culture of our country. In fact it unites great vigor, which admits of its yielding 28 to 30 tons per acre, with a generally regular form and a very satisfactory richness, which varies from 10 to 13 per cent. of sugar; it is at the same time capable of easy preservation. The foliage is vigorous and abundant, and the top protrudes slightly from the ground in such a way as to facilitate pulling without diminishing the saccharine quality of the root. The largest yields per acre we have ever known have been obtained with this variety. We have known a production of 3.95 tons of sugar per acre.

"The *gray-top* beet or the *pinkish gray* beet of the North (Fig. 5), is of all others the most perfect as to form and the most productive. It has but few leaves, and very nearly one fourth the length of the root is above ground. This part is gray, greenish, or brown; is clean and smooth like the buried portion, which is more or less pink. On the other hand it is the least rich of all the sugar beets, and is at present almost universally proscribed by manufacturers. We believe the sentence rather severe, because the gray-top beet is capable of giving, by means of a suitable culture, yields of sugar per acre which rival those of other races, and we believe it may be sufficiently improved with regard to the richness without losing its qualities of form and volume.

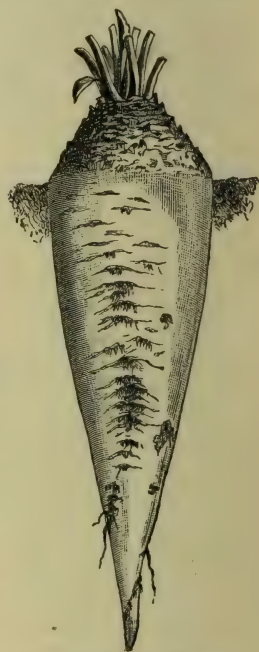


FIG. 4.—Pink-top Beet.

"The white improved Vilmorin beet (Fig. 6) descended directly from the white Si-

lesian, was brought by Mons. L. Vilmorin, by means of selection, to present, after several generations, a richness of 15 to 18 per cent. of sugar. This has been its condition for long years, and experience proves that it would be chimerical to endeavor to obtain greater richness, because the plant would then cease to grow with sufficient force. Efforts have tended in these latter years toward the improvement of the form and increase of the product, and important progress has been realized in this direction, since the improved beet, which was represented at the beginning as giving per acre a product of 8 to 10 tons, containing 15 to 16 per cent. of sugar, has given in late yields of 18 to 20 tons per acre with a richness in sugar varying from 15 to 18 per cent.

"This race has always been considered particularly suited to special conditions of culture and manufacture which are not those of France; it seems to us, however, that, in consequence of the modifications to which it has been submitted in later times, and which have increased its volume and its yield, it may be adopted in certain cases, even in our country. By growing it very closely, the inferiority of its volume as compared with that of other races is in great part compensated for, and on the other hand it has been proven by numerous analyses, especially in the competitive exhibitions of beets at Arras and Senlis, that this race surpassed all others, not

only in saccharine richness, but also in the purity of its juice, which contained less of ashes and salts than that of any other variety, an advantage of very great importance.

"This brings us to the consideration of the internal structure and composition of the beet, which, like the external characteristics, may naturally be modified by the conditions of culture and nutrition to which the plant is subjected.

"The structure of the root has been the subject of careful study by M. Decaisne, the able director of the Department of Vegetable Physiology of the Jar-

din des Plantes at Paris, and he has made a complete microscopic examination and consequent description of the minute anatomy, but in this report we shall notice only those physical characters which are manifest to ordinary vision, and the relations they bear to the economic value of the root. It is this part of the subject that has been worked up by Payen, who called attention to the appearance of the alternate opaque and transparent bands when the root is sliced in the direction of its longer axis, and of similar zones when cut in the direction of its shorter axis. Of these, he shows that the former or

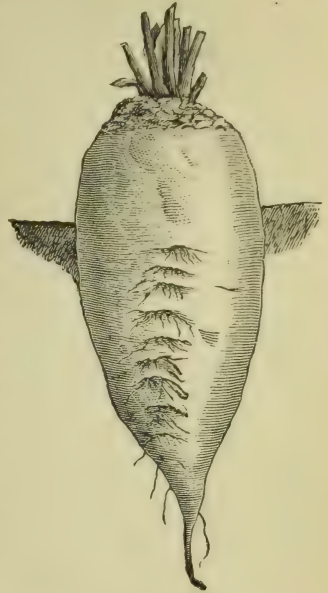


FIG. 5.—Gray-top Beet.



FIG. 6.—Vilmorin's Improved Beet.

opaque zones are the richer in sugar, and in his memoir on this subject he says : *

"If a root be cut in the direction of its length and through its center, it shows the section represented in Fig. 7. *b b b* are the parts containing the sugar. They are distinguished by their more decided white appearance; all the tissue which separates them is grayish, and contains little or no sugar. This is proven by chemical tests, by cupric liquor among others, or even simply by the taste.

"Champion and Pellet state † that—

"If very thin slices of pink beets be used, after a few minutes' exposure to the air, the zones pointed out by Payen may each be subdivided into two different zones, separated from each other by a series of black points (tubes) distributed in the form of circles, and seeming to correspond with the leaves.

"The structure would then be as follows: 1, opaque zone; 2, transparent zone; 3, opaque zone; 4, zones of vascular tissue.

"The formation of these zones seems to be in some way allied to the production of leaves, as well as the increased proportion of sugar contained in them, for Bretschneider noticed a relation between the number of leaves and of the concentric layers, and Gaudichaud found that 'the leaves of beets correspond directly with the different zones of vessels in the roots in such a way that the appearance of new leaves should always give rise to new zones of vessels;' while in connection with the above facts Champion and Pellet give the following figures, showing the relation between the percentage of sugar in the juice, the number of leaves on the plant, and the number of zones in the root :

Seed used.	Sugar per cent. per volume.	Number of leaves on root.	Number of zones.
Vilmorin seed	15.7	42	48
	14.8	39	36
	13.8	31	32
Ordinary seed of the factories	12.2	23	28
	11.5	19	20

"Payen's notions found support in the results of examinations of the parts made by Joulie, Violette, and others. Notwithstanding the earlier statements of Violette, he has published results of analyses showing that the percentage of sugar in the several parts varies inversely with the distance of the part from the longitudinal axis, and that the higher percentage is found in the opaque zones. Thus the same beet gave the following figures :

	Per cent.
Translucid zones	14.5
	13.4
	10.0
Opaque zones	15.7
	15.5
	11.2

* Comptes rendus, xxiv, 909. Quoted in *Traité de la Fabrication du Sucre*, by E. J. Maumené, t. I.

† La Bettrave à Sucre, p. 58.

“ In his earlier work, Violette found little difference in the quantity of sugar present in the two kinds of tissue, but the notions then obtained from it with reference to the location of albuminoids and salts have re-

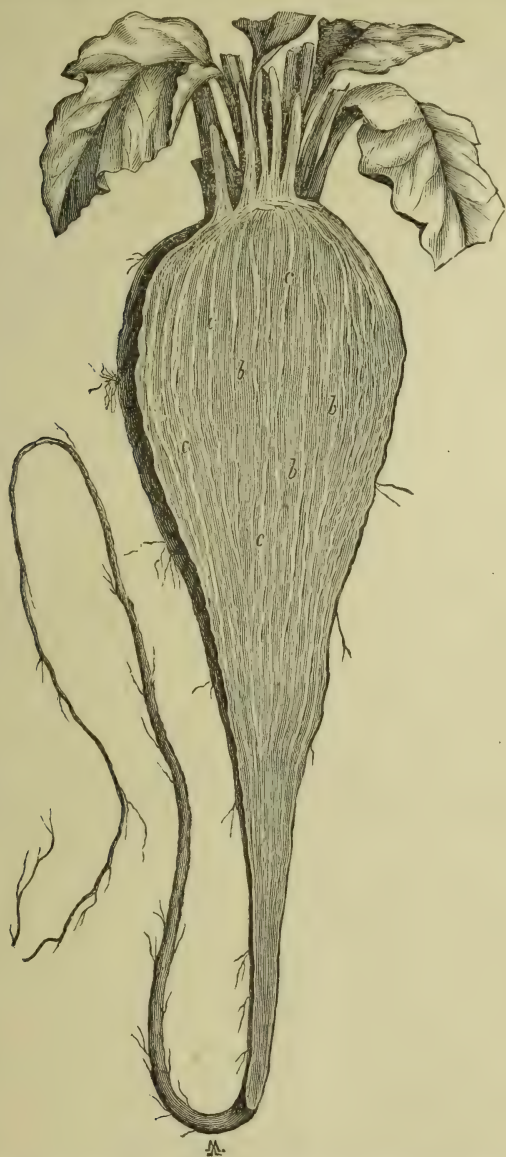


FIG. 7.—Vertical section of beet root to show anatomical structure.

ceived full confirmation in his own later work and in that of Professor Joulie. Thus, he stated—

The former (the translucid zone) appears to contain the higher proportion of mineral matters. The proportion of chlorides may be eight times as great; organic, nitric, and phosphoric acids are about equivalent, but sulphuric acid is much more abundant in the sacchariferous tissue, probably on account of the predominance of the albuminoids.

The distribution of the albuminous matters and salts is shown in the following statement giving the composition of the translucent and opaque zones :

Zones.	Sugar.	Ash.	Saline quotient.	Nitrogen of normal matter.	Nitrogenous matters of normal matters.	Nitrogenous matters per 100 of sugar.
				<i>Per cent.</i>	<i>Per cent.</i>	
Opaque zones	11.27	0.63	5.5	0.263	1.643	14.5
Translucent zones	10.00	0.84	8.4	0.230	1.430	14.3

Violette also found a higher percentage of sugar in the lower portions than in the upper portions of the root, and Joulie found that the tops contained less of nitrogen than the lower extremities. Thus Violette, cutting the root in several slices, beginning at the top, found them to contain, respectively, of sugar the following percentages:

	Per cent. of sugar.
First slice	10.42
Second slice	10.54
Third slice	10.70
Fourth slice	10.80
Fifth slice	10.94
Sixth slice	11.11
Seventh slice	11.33

And Joulie found :

	Per cent. of nitrogen in normal matter.	
Tops	0.30	0.295
Extremities of roots	0.33	0.260

The relation between the nitrogen and the sugar content of beets has been completely confirmed by the further results obtained by Professor Joulie in the analysis of beets grown under different conditions, as illustrated in the following table:

	Richness of beets in sugar.	Nitrogen in beets.
		<i>Per cent.</i>
From plots having received no nitrogen	12.55	0.264
	13.58	0.308
	15.24	0.515
	11.06	0.352
Plots having received 57 pounds nitrogen per acre	11.59	0.387
	12.97	0.429
	14.98	0.472

"This relation exists not only in the structure of the root, but also in the juice after its extraction.

Relation between content of nitrogen in the beets and in the juice.

Sugar in beet.	Parts of sugar in 100 of juice.	Parts of nitrogen for 100 of beets.	Parts of nitrogen for 100 of juice.	Nitrogenous matters for 100 of juice.
<i>Per cent.</i>				
14.4	16.0	0.45	-----	-----
13.9	15.5	0.37	0.29	1.88
13.9	15.5	0.45	0.21	1.33
12.4	13.7	0.30	0.24	1.56
11.0	12.2	0.30	-----	-----
10.4	11.5	0.19	-----	-----
9.7	10.5	0.17	0.12	0.78

"Or, calculated for 100 of sugar contained in root or juice :

Sugar per 100 grams of root.	Nitrogen per 100 grams sugar in root.	Parts sugar per 100 of juice.	Parts nitrogen per 100 sugar in state of juice.
13.9	2.6	15.5	1.8
13.9	2.9	15.5	1.3
12.4	2.4	13.7	1.6
9.7	1.7	10.5	1.1

"The mineral matters, it appears from the above analyses by Violette, exist in larger quantities in those portions of the root which contain the higher percentages of sugar, but this relation does not appear to hold for entire roots—that is, comparative estimations of sugar and ash in different roots does not seem to establish a lower percentage of ash in roots containing tolerably high percentages of sugar, and that for roots varying in saccharine richness of from 10 to 14 per cent. the proportion of mineral matters present will not vary widely from 0.90 per cent., and this view is supported by the figures given by Champion and Pellet.*

Sugar in beet.	Ash in beet.	Relation of ash to sugar, 100 to—
<i>Per cent.</i>	<i>Per cent.</i>	
14.4	1.05	7.2
13.6	1.13	8.2
13.3	0.95	7.1
13.1	0.93	7.2
12.7	1.06	8.2
12.0	0.94	7.8
11.8	0.90	7.6
11.2	0.93	8.2
11.0	0.77	7.0
10.6	1.10	8.1
10.4	0.74	7.1
Average	-----	7.6

* La Bettrave à Sucre.

“But this latter relation will not hold good for the juice after extraction, as appears from the following table:

Richness of juice.	Ash per 100 volumes of juice.	Ash compared with 100 of sugar or saline quotient.
16.2	0.78	4.7
14.9	0.81	4.8
14.7	0.73	5.3
14.2	0.78	5.4
13.4	0.77	5.9
13.2	0.75	6.2
12.5	0.77	6.1
12.2	0.79	6.1
11.8	0.76	6.5
11.7	0.79	6.8
11.5	0.80	6.9
10.7	0.73	12.3
9.9	0.72	14.5
9.7	0.71	15.6
8.0	0.76	12.2

“This question of the mineral constituents of the root, and the influence they exert upon the production of sugar and its extraction from the root, is an exceedingly important one and merits careful study. In this report it will be further discussed in the consideration of the fertilizers suitable to the crop, and the time and manner of their application. It is, however, proper to state further here, that, of the mineral matters present in the root, phosphoric acid and the alkalies, which are the most important mineral constituents of artificial fertilizers, that have the most beneficial influence upon the value of the crop, seem in the root to vary with the richness in sugar, the phosphoric acid increasing with an increase of the sugar content, and the alkalies decreasing under like conditions. These facts are fully established in the results of the researches of Professor Joulie, shown below :

	Sugar in root.	Phosphoric acid in normal matter.
	<i>Per cent.</i>	<i>Per cent.</i>
No. 1. Plot having received no phosphoric acid	12.97	0.042
	13.01	0.039
	14.98	0.054
	11.06	0.042
No. 2. Plot having received, per acre, 58 pounds phosphoric acid....	11.45	0.048
	11.59	0.060
	12.52	0.071
No. 3. Plot having received 116 pounds phosphoric acid per acre....	11.00	0.053
	13.24	0.086
	Sugar in root.	Potash and soda in normal matter
	<i>Per cent.</i>	<i>Per cent.</i>
Plots having received no alkalies	13.58	0.640
	14.98	0.415
	15.24	0.385
	11.45	0.494
Plots having received 150 pounds of alkalies per acre	11.54	0.480
	13.11	0.291

"But the quantities of alkalis absorbed by the root seem never to exceed a certain limit, as shown by Peligot, Corenwinder, Pagnoul, and Leloup, and it is by no means proportional to the quantities supplied by the soil, and the quantity of sulphuric acid necessary to saturate or combine with the alkalis contained in the ashes of beets will not vary much from 58.5 per cent. their weight. This latter relation has been fully established by the work of Dubrunfaut, Corinwinder, Ragot, Champion and Pellet, and others.

"Not only is the quantity of alkalis that may be absorbed by beets thus limited, but Champion and Pellet have found that the alkalis and alkaline earths, in the absence of those best suited to the plant, may substitute each other in the proportion of their respective chemical equivalents; a fact of importance in the study of the chemistry of soils and fertilizers.

"Of all the qualities of the root, there is none that would afford as ready and easily applicable a means of separating beets of different quality as the density, and this has long been and still is considered by many growers a strong indication of the saccharine value, but the best authorities seem to consider it a doubtful one. Dubrunfaut finds this relation to be materially modified by the presence of air or gases in the root. This view is also held by Champonnois, who, in examining roots produced in the campaign of 1874 to 1875, found that a beet having a density of 1.010 may give a juice having a density of 1.050. The figures given by Champion and Pellet are also adverse to the idea. Examination of twelve beets gave the following:

	Density of roots.	Density of juice.
Four samples.....	1.012	1.043
Two samples.....	1.020	1.048
Two samples.....	1.026	1.052
One sample.....	1.031	1.050
Two samples.....	1.033	1.048
One sample.....	1.038	1.052

"Other tests gave:

Density of root.	Density of juice.	Sugar in juice.
1.033—1.030	1.058	<i>Per cent.</i> 11.7
1.025	1.056	12.2
1.025	1.052	11.3

"Having now studied the internal structure and characters of the beet and the conditions residing within the root itself, we come to the consideration of the juice, the quantity that may be extracted, and its composition and value. I do not propose to discuss the complete analyses of the juices, but to call attention to some of the later facts that

have been worked out concerning the qualities which may affect the value or may aid in determining it. We have seen above that the deposition of sugar in the roots is almost always accompanied by a proportional deposition of albuminoids and salts, and also that the relation found to exist in the root is continued in the juice after extraction. These conditions have an influence upon the separation of the sugar which the experience of the manufacturer has taught him is unfavorable, and they will be called up again in the treatment of the subject of manufacturing processes, but in the present section we desire to call attention more particularly to the quantity of juice that may be extracted, the conditions which may modify it, and the density of the juice as influenced by the proportion of sugar present.

“We now come to the methods of selecting seed and seed-bearers, and the principles upon which they depend. Of all the experiments and investigations in the direction of improvement of this culture, none seem to have made such rapid strides in advance as in this line of work, none have given results more fruitful and of a character so well suited to ameliorate the relations between the producer and manufacturer, and at the same time be a source of profit to both.

“The initiatory steps in this work in France seem to have been taken by Mons. Louis Vilmorin, the former head of the great house of Vilmorin-Andrieux & Co., of Paris, and his methods of working, followed by similar results, are still being prosecuted with rare intelligence and skill by his son and successor, Mons. Henri Vilmorin, whose contributions to our knowledge of this and other cultures have done so much to clear up the many difficulties which surround and accompany the profitable management of the several agricultural industries.

“Of the outward characteristics which aid in determining the richness of beets, we have found the most important, as recognized in France, to be size and form of the root, its density, the number and appearance of the leaves, etc., and all these properties will be mentioned in the general rules for selection. But thus far we have failed to notice the external and internal characteristics of the seed, which have been found to have an important bearing upon the character and value of the crop; and, before proceeding to the effects of selection in securing desirable crops, we shall call attention to the relation of the character and composition of the seed upon the quantity and quality of the roots produced from it. In this connection we must again refer to the valuable little work of Champion and Pellet, in which these authors and investigators take issue with, or rather proceed further than, Walkhoff, who advises selection of the larger seeds for planting because they give more robust plants. This is true as far as it goes, but the authors above mentioned, also finding the relation of seed to the value of the crop to exist, find further that while the larger seeds give roots of larger volume and weight, the smaller seeds give smaller roots, which are richer in sugar. Thus taking two lots of seeds produced by Simon Legrand, one lot having an average

weight of 3.2 grams per 100 seeds taken, and another lot having an average weight of 4.25 gram per 100 seeds, the determination of the weight of the roots produced and their saccharine richness gave the following results :

Dates.	Average weight of four roots.	Sugar in roots.
	Grams.	Per cent.
One large seed :		
August 11	66	.....
August 20	75	11.4
August 31	125	.....
September 16	375	11.8
Two small seeds :		
August 11	30	.....
August 20	50	12.0
August 31	75	.....
September 16	232	12.5

“Dubrunfant is of the opinion that seeds having the highest specific gravity are more suitable for planting than those of lower density. He effects a separation by placing the seeds in water and after a time removing those which float, preserving those which sink to the bottom of the containing vessel. He states that the two qualities of seed behave quite differently both in germination and during growth. Champion and Pellet* quote Basset as saying, ‘It is well to do the same for seeds as is done for roots for reproduction, and choose the heavier ones, or those that fall to the bottom of a bath prepared with water and salt.’

“The chemical composition of the seed has also been the subject of study by different chemists.

“Dubrunfant,† by a chemical examination of the seeds taken from a crop of 30 acres of sugar and forage beets, and furnished him by the house of Vilmorin-Andrieux & Co., in Paris, found that the seeds of the sugar-yielding races give upon incineration a smaller weight of ash than the forage races, and the differences, which vary within certain limits, are all, with few exceptions, in the same direction. Comparing weights of seed taken and ashes produced, the proportion for the sugar-forming races varies between 4.50 and 6.50 per cent. The forage races give from 6 to 14 per cent., making an average of 7 to 8, which is very different from the proportion given by sugar-yielding races.

“It also appears that the ash of the sugar-forming races is richer in phosphoric acid, potash, and even magnesia. Thus the seeds of the sugar races give 0.004 to 0.008 per cent. of their weight of phosphoric acid, while the seeds of forage beets gives but 0.0002 to 0.0005 per cent. A similar relation exists for the potash. Thus for the sugar races a sufficient quantity is always present to develop a green color with the manganese in the ash by fusion, while in the forage races this is not the case. But if to the ash of the latter a small quantity of potash be

* La Bettrave à Sucre, p. 29.

† La Sucrerie Indigène, xiii, 428.

added, the characteristic green coloration produced by manganese is readily developed by the application of heat.

"The conclusions of Dubrunfant confirm the results of the analyses of Pellet.*

	Per cent of ash in dry matter.
Vilmorin seed (average)	6.0
Sugar beets	7.4
Forage beets	8.0

"The results of the chemical analyses of the ashes are as follows:

	Ordinary seed of the sugar factory.		Improved Vilmorin seed.
	No. 1.	No. 2.	
Potash	21.1	16.4	24.2
Soda	8.9	10.4	12.8
Lime	25.4	20.2	17.2
Magnesia	13.5	11.5	10.1
Sulphuric acid	4.0	2.8	4.3
Chlorine	4.7	4.1	4.1
Phosphoric acid	8.4	9.3	17.4
Silica	13.4		
Oxide of iron	1.2	26.4	11.0
Manganese	0.7		
Total	101.3	101.1	101.1
Deduction of oxygen for chlorine	1.3	1.1	1.1
	100.0	100.0	100.0

"On the other hand, seeds of rich beets contain a higher proportion of nitrogen than seeds of poorer beets, and at the same time small seeds contain more nitrogen than large ones, as is evidenced by the following results of examinations by Champion and Pellet:

Vilmorin seed.	Weight of 100 seeds.	Water in nor- mal matter.	Nitro- gen in normal matter.	Ash in normal matter.	Nitro- gen dry matter.	Ashes in dry matter.	Nitro- genous matter in dry mate- rial.	Alkali- nity of ash ex- pressed in SO ³ HO.	Aver- age su- gar in beets.
	<i>Grams.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>
Large seeds.....	4.130	10.9	2.66	5.4	2.98	6.061	8.6	14.9	} 15
Small seeds	0.546	11.0	3.07	5.3	3.44	5.95	21.5	13.1	
SUGAR BEET.									
Average of the varieties: Graytop, greentop, large seeds.....	4.745	12.2	2.46	6.5	2.80	7.4	16.8	-----	} 10
German, acclimated, pink top, small seeds ..	0.777	11.2	2.80	8.2	3.15	-----	19.68	-----	
FORAGE BEETS.									
Ox-horn, German yellow, large seeds.....	4.647	12.5	2.38	7.0	2.74	8.0	14.87	13.6	} 4 to 6
Pink field, red globe, small seeds	0.560	11.4	2.55	9.0	2.87	.... ..	15.93	12.4	

* La Bettrave á Sucre, p. 31.

"These relations between the richness of the beet and the composition and size of the seeds, furnish the bases of ready and valuable means of selecting the good and separating them from the worthless. The method recommended is to pass them over a screen with meshes of a given diameter, which unfortunately has never been determined, or at least stated, and to throw those which pass through in water or a solution of salt, rejecting those which float. Those which sink combine the valuable properties above described, of small size and high specific gravity. In the processes of selection as applied to choice of beets for production of seed, which really constitutes the production of new races, the end really to be attained is the ultimate development of a race, or of races, which will at the same time satisfy the demands of the producer and the manufacturer; that is, that will give a large yield to respond to the demands of the former, combined with good quality and high richness in sugar to respond to the demands of the latter. In the opinion of some of those who have devoted themselves to this work, the hope of a result such as we have described must be considered almost useless, if we depend upon the root and its characteristics, but much valuable assistance may be rendered in the attainment of this end, as we shall see later on, by the intelligent application of fertilizers to the crop and the methods of culture adopted and employed.

"In the earlier experiments in this line, those of Mons. L. Vilmorin, attention was more especially directed to the production of very rich beets, with no particular care to the size, the desire being rather to obtain beets of small size, with tapering form and smooth surface; but the late work of all engaged in this kind of experiment and research has been directed to the enrichment of races giving roots of larger volume and fuller form, making them better adapted to all soils and all methods of culture. In most cases, therefore, the work starts from the races most extensively grown.

"Vilmorin began his work by following the method employed in Germany of taking the specific gravity of the roots by plunging them in saline solutions of known density, but he soon found that, in consequence of the almost constant presence of an internal cavity, this method was inexact.

"Dubrunfaut further explains the cause of the inaccuracy of this method in the fact of the existence of air and gases within the body of the root. Vilmorin therefore resorted to the method of taking from the center of the root under examination a cylindrical portion by means of a cutting tube, and determining the density of the portion thus obtained, in solutions of sugar of known specific gravity, but these solutions were discarded on account of their unstable character, and similar solutions of salt substituted. But the loss of sugar in the sample by osmosis when immersed in the saline solutions renders this mode of procedure also unsuited to the attainment of the end in view, and he finally turned to the determination of the density of the juice itself as the readiest and

most exact means of determining the sugar content of the sample. The sample removed from the beet, furnished on grating and pressing sufficient of juice to admit of taking the weight of a metallic cube of known dimensions immersed in it, from which the density of the juice could readily be calculated. This method of determination he found to give more accurate results than any other when working upon so small a quantity of material.

"It is useless to add [he says in his paper read before the Academy of Sciences in November, 1856] that the temperature taken by means of a thermometer with tenths of degrees is carried on the register after each weight of the ingot, and that the gauge of the vases, the fineness of the suspending thread, and the identity of all the conditions of the operation eliminates errors which at first produced certain irregularities in the manner of working.

"Having thus determined the specific gravity of the juices of the various beets under examination, those considered worthy of propagation are preserved and the others rejected. The surfaces of the wounds produced in the beets examined by the removal of the sample are covered with charcoal dust, which effectually prevents any decay or deterioration in consequence of the treatment to which the roots have been submitted.

"This method was employed in the development of the race of beets known as Vilmorin's Improved, and it is this method or modifications of it, or some additional operations carried on in connection with it, that is employed to-day by the most intelligent and responsible producers of improved seed in France.

"Mr. Henri Vilmorin, who has succeeded his father in the work, combines the method with examination of the sample of juice, after the determination of its specific gravity, by means of the polariscope, while others employ, as supplementary to the method, estimation of the sugar by means of the copper test.

"But notwithstanding the unfavorable conclusions concerning the method of selection, based upon the density of the roots as determined by immersing them in solutions of molasses or salt of differing but known strengths, it is still used by many of the leading seed-growers in the north of France. M. Demiatte, in an article on the subject of selection of seed-bearers, states* that he proceeds as follows, according to Brabant's method: Select subjects weighing at least 700 grams ($1\frac{1}{2}$ pounds). For determination of their density they are thrown into a vat partly filled with a solution of molasses, having a density of 2.5 degrees by the densimeter; those roots which float are rejected; those which partly sink are preserved for the production of seed called No. 3. Those which sink completely are thrown into a second vat containing a solution similar to that just described, but having a density of 3.5 degrees. Those which float here are preserved for production of seed known as No. 2. Those which sink to the bottom are of course of the best quality, and are used for production of seed No. 1.

* Journal des Fabricants de Sucre, 1879, February 19.

"We have seen that the generally adopted opinion concerning the best form of beet to be chosen for production of high yields of sugar is to the effect that the long tapering ones are the most valuable; but this opinion is likely to be subject to modification in consequence of the results of later observations upon the constitution of the improved varieties and their power to resist the deteriorating influences to which they may be subject in the varying conditions of soil and culture. The tapering, richer, improved races, descended from German stock, have been found more subject to disease in France than the poorer races of the country, and M. Decrombecque, at Lens, conceived the idea of incorporating within the latter the sugar producing-qualities of the former, and at the same time retaining the hardiness for which the commoner races are well known. To attain this end he had recourse to the method suggested by Walkhoff,* who believed that the saccharine richness of beets may be improved by crossing, and who was able by using seeds of Frickenhouse, and the method referred to, to obtain beets the juice of which marked 18.8 degrees, Balling, and containing 16.5 per cent. of sugar, starting with varieties the juice of which showed but 17.8 degrees, Balling, and containing 16.35 per cent. of sugar. In planting, the roots were placed in close contact so that the blossoms touched each other, and the slightest agitation was sufficient to effect the transport of pollen.

"But the results of the experiments and of the practice adopted by Mons. Decombrecque† are rather more striking than those obtained by Walkhoff. He noticed when he began his work at Lens that the Silesian beet grown upon a rather shallow soil, and especially when manured with stable manure containing considerable straw, in the spring (well known to be a bad and injurious practice), was hairy, fusiform, and wanting in weight. At the same time the white beet of the country, with green top, gray flesh, and obtuse form, flourished and developed well, though remaining pyriform in the same field in which the Silesian fared badly. The question was to produce a beet having the hardiness of the one and the richness of the other. He chose from his crop the best formed, richest subjects, of *size above the average*, well covered in the ground, and then, observing the same care, chose specimens of the country roots called *toupie* (about the poorest of all the beets grown), and the beets thus chosen he preserved for seed. In planting he combined them in the proportion of five plants of the Silesian with one of *toupie*. In collecting the seed he carefully preserved separately that from the Silesian varieties and that from the *toupie*, and in subsequent sowing used only that from the Silesian. He found that the character of the Silesian beet had changed, and that the beet had the obtuse form. However, after the third year of planting the modified seed, he found that the good qualities of the Silesian had disappeared, and he had only the low-grade beet of the country. His subsequent practice, therefore, was

* See *La bettrave à sucre*, par Champion and Pellet.

† *La sucrerie indigène*, xii, 434.

to grow two or more acres of Silesian, and from the crop produced to select those he needed for seed, and these roots he mixed with roots from the ordinary crop in the proportion of 1 to 3, and thus secured continuously the hardness of the one and the richness of the other combined.

"With the indications given by Mons. H. Vilmorin in his description of the leading races of beets grown in France, and the methods described in the preceding pages, it will not be difficult for the prospective grower to determine the varieties that will be best suited to his purposes, or to produce new races through which the results he desires may be obtained, but it will not be out of place here to call attention to the experiments of Mons. Derome at Bavay (Nord) made with seeds obtained from various producers with a view to the determination of the best varieties for cultivators to grow in order to secure a crop of quality and quantity to be satisfactory both to themselves and the manufacturer. This he conceives to be a variety that will give the most sugar per acre, in condition to be most easily extracted in the greatest weight. Without entering into the details of his experiments we shall simply give in the following table the names of the varieties of seeds sown and the results obtained:

Varieties.	No. of plants per acre.	Yield per acre.	Density at 60° F.	Gross yield in sugar.	Price of beets per ton of 2,200 pounds.	Sum realized by the grower per acre.	Sugar of 88° extractable.	
							Per 100 pounds of beets.	In quantity harvested per acre.
		<i>Tons.*</i>	<i>°</i>	<i>Per ct.</i>			<i>Pounds.</i>	<i>Tons.*</i>
1. Long pink toupie.....	23, 205	20.1	5	8.431	\$4.00	\$80.00	4.69	0.94
2. Silesian, pink, fusiform.....	34, 210	18.0	5.70	10.766	4.64	83.00	6.84	1.23
3. Silesian, pink, fusiform.....	32, 388	15.9	6.40	12.841	5.64	81.00	8.34	1.33
4. Silesian, white, first choice.....	32, 344	11.9	7.15	13.769	6.80	78.00	9.27	1.07
5. Silesian, white, second choice.....	32, 266	16.0	5.95	10.921	4.94	79.00	6.84	1.03
6. Silesian, white, acclimated.....	35, 060	15.9	6.10	11.473	5.16	32.00	7.34	1.16
7. Silesian, white, acclimated.....	34, 656	14.9	6.15	11.194	5.48	65.00	6.97	1.04
8. White pink top.....	37, 627	16.8	5.75	11.538	4.70	79.00	6.50	1.09
9. White improved.....	32, 759	11.4	7.20	11.368	6.92	78.00	8.68	0.99
10. White green top.....	34, 210	15.3	5.90	10.912	4.88	73.00	6.89	1.05
11. Pink acclimated.....	31, 983	13.8	5.90	10.736	4.88	68.00	6.67	0.92
12. White silesian.....	32, 874	14.2	6.16	11.126	5.10	73.00	6.93	1.98
13. Pink silesian.....	33, 966	15.1	6.05	10.825	5.08	79.00	6.69	1.01
14. Pink silesian.....	33, 400	17.9	5.45	9.957	4.36	78.00	6.02	1.08
15. Pink Brunswick.....	31, 583	17.5	5.40	9.709	4.32	75.00	5.86	1.02

* Of 2,200 pounds.

"He concludes from the figures obtained and here given that the best beets to be grown, and which he considers the races of conciliation, are those represented by the numbers 2, 3, 5, 6, 7, 8, 10, and 14. If sold according to the density of the juice and the scale of values in the form of arbitration adopted by the sugar manufacturers at Lille,* the grower will receive a higher return per acre than with any of the other varieties mentioned.

* See later on in discussions of relations between the grower and manufacturer.

"In this connection the results of the experiments of Deherain are relevant and interesting. He says:*

"It follows from our experiments and analyses that beets submitted to different modes of feeding or fertilizing, preserve in their development the native qualities of the seed, i. e., their race.

"In several of the experiments, pink tops and improved Vilmorins were submitted to exactly the same conditions, same sterile soil, same manures given in equal quantities, yet in one case while the pink top contained 7.5 per cent. of sugar, the improved beet contained 16.2. In another case when the fertilizer was more nitrogenous, the richness of the pink-top beet fell to 5.5 per cent. and the Vilmorin to only 13.4. This shows clearly the influence of race upon the saccharine quality of the beet. The conclusions would appear premature were these experiments the only evidences to support them, but they are also confirmed in the results of experiments made by Mons. H. Vilmorin at Verriers, according to Professor Deherain's suggestions.

With reference to the type of beet to be chosen, Mons. Demiatté† says:

"The nature of the soil and method of culture being known, the form should change with the nature of the soil; should be long and tapering in deep sandy or alluvium soils; short and more obtuse in shallow soils like that near Arras, where the thickness of the arable layer will not exceed 6 inches. But whatever be the type chosen the top of the mother beet should not protrude from the soil more than one-fourth its total length.

"With the facts and figures presented, which have all been worked out in France by careful experiment and investigation, no further comments on the different French races will be necessary. The selection of varieties for cultivation can best be left to the reader. We believe, however, it will be of interest, and we shall, therefore, conclude the consideration of this subject by giving the names and addresses of several of the leading producers of seed in France who made exhibition of their products in the late Paris Exposition of 1878, with short notices of the character of their exhibits.

Desprez père et fils, Capelle.—The varieties produced are No. 1, white or pink, containing 15 to 18 per cent. sugar, requiring deep, rich soil, plenty of manure, and excellent culture; yields 16 to 20 tons per acre. No. 2, white or pink, 12 to 15 per cent. sugar, for ordinary soil, fertilizing, and care; yields 20 to 25 tons per acre. No. 3, 10 to 12 per cent. sugar for inferior soils and cultures; yields 25 to 30 tons per acre.

"*Simon-Legrand, Auchy.*—Different varieties containing 12 to 20 per cent. of sugar; some varieties of special selection containing from 20 to 23 per cent.

"*L. Dervaux-Ibled, Wargnies-le-Grand.*—Cultivates seed by special method of selection depending upon taking specific gravities of cylin-

* Annales agronomiques. † Journal des Fabricants de Sucre, February 19, 1879.
25474—Bull. 27—5

dric samples cut from the roots and immersing them in saline solutions of given strength.

“Brabant frères Onnaing.—Cultivate seed of special variety bearing their name; claimed to produce 21 tons per acre, of beets of average richness of 14.88 per cent. of sugar.

“Vilmorin-Andrieux & Co., No. 4 Quai de la Mégisserie, Paris.—Produce seed from five varieties, given in the table below, showing the industrial value of each variety.”

	Green-top beet.	Improved Vilmorin beet.	French races.		German race.
			Pink top.	Green top.	
Yield per acre long tons..	33. 117	16. 639	30. 121	30. 049	23. 360
Sugar, per gallon of juice .....pounds..	1. 12	1. 63	1. 24	1. 20	1. 30
Sugar, per acre .....do.....	8. 437	5. 601	8, 754	8, 595	7, 029
Sugar, per long ton of beets	149. 6	290. 4	182. 6	173. 8	222. 2
Approximate industrial yield..per acre..	4. 468	3. 095	4. 893	4. 739	2. 308

THE IMPROVEMENT OF THE SUGAR-BEET.*

“‘The improvement of the sugar-beet’ is a term essentially capable of great expansion, inasmuch as its significance embraces the bringing about of the fullest adaptation of the beet, to the industries of sugar and spirit manufactures, and under very varying conditions on the one hand of the manufacturing process, and on the other of the operation of the tariff laws.

“The question, however, may be so far restricted as to consider one of two purposes—either, according to the laws of physiology and agricultural chemistry, and to the observations of practical experience, by seeking that process which will yield the greatest amount of sugar per acre at a given cost, or by following artificial methods, endeavor by obedience to those, to obtain such beets as will give the greatest profit. By the adoption of one of those courses beets will be grown best adapted to the manufacture of sugar and spirit in France.

“The improvement of the method of beet-production is not more difficult with these roots than in the examples of other plant kinds; in fact, in given respects, it is more simple and stable. It is quite possible to establish given properties and specialities in the beet providing those properties are not in actual opposition to the nature of the plant, and that they are capable of transmission to the following generation. In brief, those given specialities and characters are to be secured by selection. Nevertheless, not every man will succeed in such a course of improvement by selection. It is necessary (1) that the cultivator shall

* By H. de Vilmorin, *Sucrerie Indigène*, vol. 34, p. 328, and *Zeitsch. Rübenzucker-Industrie*, October, 1889, p. 888.

have a clear grasp of his purpose, and (2) that he shall be fully cognizant of the nature of the plant and of the conditions of its growth.

"The first of these conditions is a general one and applies to all experiments. The second condition, however, requires a knowledge of the advantages and disadvantages of the varieties chosen for cultivation, and that the conditions of growth shall not be artificially influenced, or at least not in a way prejudicial to the strengthening of the natural proclivities of the plant. The latter condition is of the first importance and demands all consideration. The rules for such experiments in the cultivation may be given as follows:

"(1) The individual plants which are selected for cultivation must be planted under those conditions which allow of the full development of the natural merits and demerits of the variety.

"(2) The experiment plants must, moreover, be grown under the same conditions, in respect of the length of the period of growth, the distance between the single plants, the properties of the soil and fertilizers applied, as the roots grown for the actual making of sugar.

"In order that the size, form, the sugar-content, and the purity of the juices of given varieties may be properly adjudged it is essential that the roots shall have been grown under the conditions in which those several characteristic features and properties could be normally developed. Strange to say, a rule so natural has been consistently ignored, and beets have been provided for purposes of the laboratory strongly at variance with those requirements. The soil has been very deeply cultivated, and the roots grown in the closest proximity in order to produce beets long and thin and free from side roots, and, naturally, rich in sugar—a directly opposite procedure were probably the most reasonable.

"As an example of a bad quality may be given the nature of certain roots, or varieties of roots, to run to seed. Roots for propagating must be selected which are free from this inclination; and, in order to provide a trustworthy test, the seeding must be made very early which thus induces the disposition to 'run.' The plants which do not show the 'running' disposition should be selected for further propagation.

"Another example: How is it possible to sort out the representatives of a very fibrous nature when the roots are grown under conditions whereby the side roots are not developed?

"As the average weight of the roots is a matter of consideration it may be observed that both home and foreign seed-growers aim at the production of beets weighing from 600 to 1,200 grams.

"As the characteristics of beets are several the selection must be spread over, and depend upon, certain different observations. The size, form, color, leaf growth, the season of growth, as well as the period of maturity, are suitable for such observation, and experienced seed-growers will be readily able to make their distinctions from the observation of those several physical properties. The determination of the

sugar-content and of the purity of the juice depend upon purely chemical estimations. The specific gravity of the roots and of root-juices is determined, and the sugar quantity is ascertained by means of the polariscope and copper solution. The determination by use of the polariscope is to be preferred for the reason that little time is required and the purity of the juices is observed by the same process.

"It is not enough, however, nor is the main purpose accomplished, when beets have been secured, rich in sugar, of a pure juice, and possessing the several physical qualities which have been specified. The greater purpose is to distinguish those beets in which the given properties and values are fixed, and which are capable of transmitting those specialities to successive generations; in other words—which are true in propagation.

"I have, with great labor and care, endeavored to secure seeds and beets with fixed characteristics by planting the seeds of selected representatives and growing those with the single view to the observation of their hereditary values. At the end of the year those plants which had not preserved the given physical properties were thrown out and the 'true' beets preserved for propagation.

"In my opinion, the problem of securing practically the best beet seeds is to be attained by observing the following means:

"(1) The organizing of the production of beets possessing definite and fixed properties and specialties by the use of the most rigid system of 'selection.'

"(2) A system of cultivation and planting most approved, in view of economy, by sound experience. These rules may encounter considerable controversy, but they are resting upon a long personal experience and the opinions and practices of French and German experts and practical men.

"The growing of seed from small roots—250 to 400 grams—has no disadvantage in respect of the value of the seed; nevertheless this will only apply in the instance where the practice is not repeated with the seed from the same. Seed grown from beets of a large growth can not be so economical as from the smaller size, and when the condition attaching to the use of the smaller beets is observed, no disadvantage occurs.

"Amongst the many most excellent kinds of French beets, one in special must be mentioned, although I may stand in a close relation to its history. The beet was introduced by my father, and I have given all possible care and endeavor to increase the form and weight-producing quality to the highest degree compatible with a proportional increase in the sugar-yielding value of the same. And, in the face of all controversies, I must maintain that no other system of culture would have established and sustained the same excellence of the beet in respect of form, weight, and purity of the juice as the system adopted in our experiments and specified in the rules already laid down.

"Amongst other French representatives may be mentioned the Brabant-beet, whose habit of growth is typified by the upright leaf, long, thin, and smooth root, and distinguished by its richness in sugar. This kind may be classed as one of the best French varieties and distinctly differing from the German.

"Of many excellent German beets which have been introduced into France the 'Klein-Wanzlebener' has had an experience of ten years in our climate and appears to thrive better even than in its native sphere. The variety is known by an abundant leafage of a bright green, and broad, multiplied roots.

"The 'crossing' of different varieties is a rich source of varying kinds, but the course has a fatal effect upon the hereditary principle and properties. The characteristics of the 'cross,' which may be the product of a single year, are transient and may be lost in as short a time as they require to be produced.

"I would specially state that the assertions which I have made in respect of the best beet kinds are not merely devolving upon my own experience, but may be supported by comparison with the statements of other experimenters.

Experiments of M. Dupay in Chervy-Cossigny, given in the year 1888.

	Yield.	Sugar per hectare.
	Kilograms.	Kilograms.
Average of four French beet cultures	36.000	5,665
Average of four German beet cultures	35.140	5,537

Experiments of MM. Porion and Déhérain—1888.

	Yield of roots.	Sugar in juice.	Sugar in beet.	Money value.
	Kilograms.	Per cent.	Per cent.	Francs.
French	43.100	16.74	14.77	1,659
German	45.100	16.39	14.50	1,623

"The yield is in favor of the German, but the money value is greater actually in the French."

Experiments of the Sugar-House Bourdon (Puy-de-Dôme).

	Yield per hectare.	Density of juices.	Sugar per hectare.
	Kilograms.	°	Kilograms.
French	44.854	7.9	7,970
German	40.296	7.7	6,979

VARIETIES OF BEETS.

The varieties of beets which are cultivated are perhaps more numerous in name than in distinct qualities. In France the White Improved Vilmorin beet is very largely cultivated. Its general type is shown in the following figure :



FIG. 8.—White Improved Vilmorin Sugar Beet.

This beet has been the result of thirty years of methodic and persevering selection based upon the lines above indicated. In regard to its preservation it is recognized that it holds its sugar content better than any other variety. In those factories in which the Improved Vilmorin is manufactured in connection with other varieties it is the custom to reserve this for the end of the season and to work up the less reliable beets at an earlier date. It is also said to resist better than any other variety the unfavorable influence of certain characters of soil and of certain manures. In black soils, rich in organic matter, it will give great industrial results, while most other varieties of beets become watery or saline in excess. Excessive quantities of nitrogenous fertilizers, which are carefully excluded from ordinary varieties, can be applied with safety to the Improved Vilmorin. A great number of experiments has shown that this can be done without serious deterioration in the quality of the sugar and with a considerable increase in weight. From thousands of analyses it has been established that the percentage of sugar which can be obtained with this variety is about 16. In regard to its yield under favorable conditions it can be stated to be between 30 and 35 kilograms per hectare.

Perhaps more important for general cultivation than the Vilmorin variety is the beet known as the Klein-Wanzleben, which at the present time has probably a wider cultivation than all other sugar-beets. The general character of this beet is shown in the figure.



FIG. 9.—Klein-Wanzleben Sugar-beet.

This beet has a conical root, straight and even, quite large at the head and rapidly tapering. It is distinguished from the Improved Vilmorin by its brighter color and its lighter-colored leaves, which are beautifully undulating or scalloped about the edges. Coming from a cross in which the Improved Vilmorin entered largely, the Klein-Wanzleben is to-day a fixed variety, and is equally well produced in France and Germany. It succeeds equally well in soil of an alluvial nature and mean richness and on level plateaus. In soils very rich in humus it ripens poorly and loses much of its richness. Like the Vilmorin Improved, toward the end of vegetation its leaves are completely spread. In those conditions of culture where the Improved Vilmorin gives 34,000 to 36,000 kilograms, the Klein-Wanzleben will give 40,000 kilograms. It is, however, always inferior to the Improved Vilmorin in point of view of its saccharine richness, which the whiter and more watery appearance of its flesh would make known at first view. Nevertheless from 13 to 15 per cent. of sugar can be obtained in the beet.

The Brabant sugar-beet is altogether different in aspect from the preceding varieties. It is long, rising well above the level of the soil, carrying a foliage vigorous in growth and upright in position. This variety would seem at first view to have come from the white varieties

used for forage; nevertheless its great vigor, its abundant production, and its content of sugar sufficiently high make it a beet quite valuable in those countries where the tax is placed upon the amount of sugar made rather than upon the beet. The Brabant Sugar-beet will give easily 50,000 kilograms per hectare and may be made to contain 12 per cent of sugar. Its general appearance is indicated in the figure.



FIG. 10.—Brabant Sugar-beet.

In France the adoption of legislation placing the tax upon the beet itself has not entirely banished the Brabant variety, but it has succeeded in transforming it into one of greater richness in sugar. This variation of the Brabant beet has been called the French Rich Sugar-beet, and seems destined to have a brilliant future, preserving in its general aspect, and notably in its foliage, many of the characteristics of the Brabant. The French Rich Beet differs distinctly from it in the fact that it grows entirely under the soil, is more slender, with a more

reddish skin and more compact flesh. Its yield is superior to the Vilmorin Improved and even to the Klein-Wanzleben, amounting to from 40,000 to 43,000 kilograms per hectare in good conditions. Its general appearance is indicated in the figure.

The content of sugar of this new variety is rarely inferior to 14 per cent on the weight of the root.



FIG. 11.—White French Rich Sugar-beet.

The Imperial sugar-beet is one which is largely grown throughout Europe. It has a regular conical outline with a top-shaped top and with leaves with rather short stems. There are different varieties, such as the Old Imperial, Improved White Imperial, and the Improved Rose Imperial. Other varieties which are also grown are the Electoral, the Improved Elite, the Improved Imperial Elite, the Imperator, Olive-shaped, and the Excelsior.

Some of the most celebrated firms in Europe producing sugar beet seed are Vilmorin-Andrieux & Co., Maison Simon Legrand, of Paris; Messrs.

Brumme, of Bernburg, Germany; Dippe Bros., Quedlinburg, Germany; Ferdinand Knauer, of Gröbers, Germany; Le Maire frère et sœur, and Florimond Dèsprez.

BEET-SEED AMELIORATION.

For many years past there has been a constant improvement in the quality of sugar beets raised in France. While it is true that for more than twenty years beets have been grown with high sugar percentages, their irregular shapes and special requirements did not bring them within the practical demands of farmers.

The best method of selection is yet an open question, and the seed-growers do not all agree as to the most desirable size of the "mother." Some use roots weighing about one-fourth pound, and several agronomists maintain that 2 or even 3 pounds (?) is not too heavy a weight. While in the latter case the seeds attain their full development (whether this is the case with the smaller types it is difficult to decide), many experiments appear to prove that there is very little difference in the seed in the two cases.

Pellet recommends that "mothers" be planted very close together, with the view of preventing any further development of the root, and so that the entire vitality of the plant may be expended in this seed development. Another argument in favor of very small beets is, that there is an economy of space, and the planting may follow on the soil that had already yielded a crop the same year; the expenses also are less.

One argument is that the "mothers," with their numerous stalks, require room, and hence the importance of roots of a certain size and planted at reasonable distances apart. On the other hand, the stalks of small beets attain a far greater height, owing to their desire (so to speak) to derive from the air the oxygen which close spacing certainly keeps out. Again, some assert that with large roots and stalks the size of the seed and quality is inferior to that obtained with the smaller roots. These facts are mentioned simply to show how very difficult is the question of selecting and ameliorating existing varieties of beets.

Peligot, Leplay, Pellet, etc., have concluded upon some interesting facts respecting the requirements and the changes "mothers" undergo during the process of seed formation. The stems, leaves, and seed, yet green during July, do not contain sugar in their composition, but the sugar of the "mothers" constantly diminishes from the time the second growth commences until the seeds are matured. The density of the juice diminishes in the root and increases in the stalks, then in the leaves. Vegetable acids, with potassic or lime base, exist in the juices of the root and stalks.

Respecting the potassic and lime salts, there appears to be an ascending movement between the soil and the stalks, leaves, etc. Carbonic acid in the mean time undergoes the same changes as it does during the first year's vegetation. An interesting fact is, that the requirements

of vegetation for potassic and lime salts during the second year is very much greater than during the first year's growth. These salts in combination with vegetable acids, in solution, appear to have important influences on the formation and quality of the seed obtained.

As early as 1850 Vilmorin called attention to the possibility of selecting beets, by depending upon the proportion that exists between the density and the sugar percentage. The classification was very simple, and consisted in placing the roots in solutions having a specific gravity known in advance, prepared with chloride of sodium and water. The selection, according to the density of the juice, followed; but while the results were more satisfactory than the foregoing, it was faulty, and it does not necessarily follow that the richest beets are those having juices of the highest specific gravity. The roots resulting from this selection were very irregular in shape, and could not be used in the factory; they were also difficult to harvest.

The size of the neck, shape of the leaves, their abundance, etc., were elements to be considered in the outer characteristics of selection. M. Desprez's selection has demonstrated that beets which have been selected according to analysis will result in seed-yielding beets testing 2 per cent more sugar than those which have not been analyzed. Some years since it was customary among many seed-growers in France to send seed to Germany and receive them back from that country to France. The roots raised from those "mothers" were selected; a change of climate was *supposed* to have been beneficial.

Twenty varieties of seed were experimented upon by Desprez; all had been produced upon the farms. It was noticed that beets penetrated the soil very much more during a dry than in a wet period. An abnormal number of beets went to seed the first year (42 per cent.); this means a large amount of sugar; it is contended, however, by some that this loss is never more than 2 per cent. Beets of considerable length and having rough skin gave the largest yield, and were but little affected by insects. The observations on influence of distance between beets in rows upon the sugar percentage and yield are worth recording.

It was concluded that upon an average soil there should be cultivated about seven to eight beets per square meter; on well prepared soils with suitable fertilizers the number could be twelve to fifteen. The spacing between roots should depend upon the soil and fertilizers used; selection of the best variety best suited to a given locality also depends upon these factors.

Without doubt the most important beet-seed exhibit at the Paris Exhibition was that of M. Legrand, who devotes annually 50 to 55 acres to seed-raising. Most of this seed is used in the vicinity of his farm and the remainder is sold for a nominal sum, considering the quality and the pains taken in selection. "Mothers" exhibited were much larger than those shown by other exhibitors, and yet the sugar percentage was in some cases over 20. An important fact is that in the selection no beet is accepted unless it weighs at least one pound.

The beets are taken from the field by a harvester, with the view of avoiding bruises which occur with use of spade, etc. This work is performed by the farming hands, who make at once a preliminary classification. Circular piles are formed with leaves outside to protect them from any changes in the weather; but soon as possible these leaves are removed and a second and more complete assortment follows; then the roots are placed in small silos. The laboratory selection by the Violette method is carried out on a most extended scale, there being made 2,500 analyses per diem, and a total of 175,000 during the season of 1889. When in 1885 the raising of superior beet seed was determined upon, the roots on M. Legrand's farm did not test on an average over 11 per cent sugar, and now the standard has reached 16 per cent.

M. H. Sagnier, a well-known agricultural expert, says that during a recent visit he found that two-fifths of the total roots raised by M. Legrand tested 15 to 17 per cent sugar, two-fifths from 17 to 18, and one-fifth had a saccharine percentage beyond the latter limit. The richest beets are known as "grandmothers," and are used for the production of seed which is planted alone for obtaining "mothers;" those of the second category are used for the same purpose. The seeds from the lateral stalks always give the finest grain. Before the flower appears the central and lateral stalks are pinched off, resulting in a greater development and vitality of those remaining; and even before the "mothers" are planted the extreme end of their necks are sliced off.

There can be no doubt of the importance of this extended system of analysis, with the view to a scientific selection, as carried on by Legrand. A member of the jury at the Paris Exhibition, however, reproached the seed-grower in question for the trouble he had taken, as the shapes were so regular that outer signs alone would have been sufficient to decide the quality. There appears to be no limit of time or amount of money that can deter Legrand from obtaining the desired results in beet raising; and his methods, while in many respects original, are destined to have a great future.

In discussing the history of the sugar beet it is too frequently asserted that the best varieties have a German parentage; we are assured that the original types, as adopted by Legrand (who has constantly in mind a beet possessing considerable density and yet juicy) has been obtained after years of careful selection from "mothers" of French origin entirely.

On the Carlier farm the "mothers" are taken from the best fields that are sown in April, and a cultivator is used four to five times before thinning out; eighteen to twenty beets are grown to a square meter. The first selection is made on the field at once after harvesting, the regular shape and size, denoting maturity and quality, being the main basis for the preliminary selection. The roots chosen are silotted near the laboratory, and the second selection is made in January; the beets preferred weigh 350 to 600 grams. For many years it was argued that the greater the density of the beet the higher its saccharine quality, hence a selection offered no difficulty. Later experiments soon demonstrated that

such methods were not reliable; as a preliminary operation, however, there can be no reason why baths of salt water or molasses, having a known density, could not be used, throwing aside those roots which would float in the bath of 1.045 density, and keeping, say, three piles from 1.045 to 1.050, from 1.050 to 1.055, and from 1.055 to 1.060.

The classification as adopted by Carlier, depending upon the density of a core taken as a sample from the beet, was not entirely satisfactory; frequently the volume of air, etc., a beet may retain in its composition is to be considered. According to Dubrunfant, beets retain 115 cubic centimeters of air per 1,000 grams in weight, and frequently there is, owing to this fact, considerable difference between the density of beets, considered as a whole, and the juice. At the Wargine-le-Grand farm these variations were shown to be:

Density of entire beet.	Density of juice.
1.012	1.043
1.020	1.048
1.025	1.052
1.025	1.056
1.030	1.058
1.038	1.052

This fact alone would condemn any method of solution depending upon density.

In the Lemaire system of selection roots weighing 500 to 800 grams have preference; such as remain well under ground, and having a special depression on both sides, commencing with the neck and ending with the tip end. Legrand, Lemaire, and others attach considerable importance to these outer characteristics, and many maintain that the more pronounced they are the higher will be the saccharine quality of the root.

Lemaire and others also maintain that their careful selection by outer signs, combined with chemical analysis, has enabled them to create new types; in fact, most seed-growers may claim that their special varieties have been "creations." The beets in the latter case are placed in silos, where they remain until February or March. The experimenters last named and others consider it a mistake to commence analysis sooner, as there would be no certainty as to the preservation of the roots, a quality as essential as the sugar percentage. The one without the other has but little importance, as they both may be transmitted to their descendants.

When we consider that beets must be kept in silos frequently four to five months before being used at the factory, the element of preservation becomes of the first importance. Those roots which have undergone little or no change in their saccharine percentage during the several months of preservation are selected, and there is very little doubt that just as their conservation was satisfactory so will be the beets raised from the seed they furnish,

M. Lemaire informs the writer that experiments were made with seed from beets having lost in sugar during their silotting and were compared with seed from those that retained their sugar percentage. The conclusion was just as expected; the roots from seed that kept well had a higher sugar percentage than others. The hereditary quality of beets should be constantly borne in mind in these selections and ameliorations.

M. Lemaire also states that all analyses made by the copper test are repeated with the polariscope, and in most cases their seed give roots with a high co-efficient of purity. The "mothers" when planted are placed at distances of 60 to 70 centimeters. About one month before maturing the tops of the highest stalks are cut off so as to permit the sap to center itself upon the seed. Laurent-Mouchon has had some little reputation of late years, his beets being of a satisfactory quality. Their selection does not differ from that above mentioned.

To give some idea of the importance of growing forms of seed as above described, we may mention that the Legrand estate at Besny has over 200 acres planted in beets for the factory at Loan, the yield averaging 10 to 12 tons to the acre, and roots testing from 12 to 16 per cent sugar. About 55 acres are devoted to seed-raising; 3,600 roots ("mothers") are planted to the acre. In the Desprez seed-producing farm wheat follows the production of "mothers" in rotation; barn-yard manure, rags, etc., are also used to the value of \$10 to \$130 per hectare. It is considered that the "mothers" absorb two-thirds of the fertilizers, the other one-third remaining for the wheat. Of the farming lands two-fifths are devoted to beet-seed cultivation, two-fifths to wheat, and one-fifth to beets, flax, etc. All soils used for beet cultivation are worked to a depth of 35 centimeters. Soils intended for the "mothers" are worked in two operations, about 20 centimeters in depth in the fall and the remainder in the spring, so as to plow under the fertilizer.

The "mothers" when growing have the cultivator passed between the rows four or five times. The area under cultivation at Orchies is 432 hectares, of which 150 hectares are under Carlier's direct supervision, 54 hectares in "mothers" for seed, and 30 hectares in beets of inferior quality intended for cattle feeding. Efforts are made to keep these separate so that there will not be hybrids formed by the combination of their pollen. The Lemaire plantation at Nomain consists of 275 hectares, in five farms, on each of which a special variety of seed is produced. Besides this 400 hectares of beets are controlled for an agricultural distillery. The annual production here is estimated at 500,000 to 600,000 kilograms of beet-seed.—(The Sugar Beet, vol. 10, No. 4, 1880.)

SOIL, PLANTING, AND CULTIVATION.

PREPARATION OF THE SOIL.

Land which is to be planted with beets, if manured with farm-yard manure, should have this coating applied in a well-rotted state in the autumn and plowed in to the depth of 5 or 6 inches. In the spring the

soil should be plowed to a greater depth, from 8 to 10 inches, and if the subsoil be at all hard a subsoil-plow should follow, loosening the subsoil to the depth of 12 to 15 inches. The surface of the soil is then reduced to the proper tilth by harrowing, and, if necessary, rolling to break up the clods. It should not be forgotten that much of the cultivation of the beet may be accomplished in this way before planting and the process of seeding should not begin until the surface of the soil is in the perfect condition mentioned above. Care should be taken not to apply fresh or unrotted stable manure, or any other manure containing large quantities of undecomposed organic matter, to a field seeded to beets except in the manner described above.

It is scarcely necessary to add that care must be taken in plowing the soil to have it in the proper condition of moisture, since, if plowed too wet, it is likely to bake, and if too dry clods may be formed which will be difficult to reduce to the proper state of tilth. A field prepared as above will afford the beet opportunity for growth downward, thus preventing its being projected above the surface of the soil. It will also guard the beet against the dangers of excessive moisture or drought, as stated above.

SEEDING.

In small plots the beet seed can be placed in the soil by hand. For large fields drills are provided which are built to operate precisely on the principles of ordinary grain-drills, the opening for the seed made to correspond to the size of the beet seed. Simple drills may be used or compound drills for planting the seed and distributing fertilizers at the same time, such as are used in sowing wheat and other cereals. A convenient drill for this purpose is represented in Fig. 12, the Planet, Jr., No. 2 seed drill, made by S. L. Allen & Co., Philadelphia.

Distance of rows.—No definite rule can be given for the space between the rows of beets. In an ordinary soil this space should be about 18 inches. In very fertile soil the rows should be placed closer together, in a less fertile soil farther apart.

The distance at which the beets should be placed from each other in the rows also varies according to the nature of the soil and climatic conditions. In general, it may be said that there should be one plant for each 6 inches.* In very rich soils the beets should be closer together, and in very poor soils they should be farther apart. With rows 18 inches apart, the beets planted at a distance of 6 inches in the rows, the number of beets per square yard would be twelve and the approx-

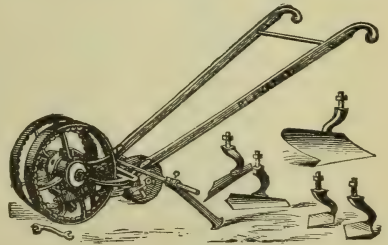


FIG. 12.

* The beet seed should be planted close together. Some authorities recommend fifteen pounds per acre.

imate number of plants per acre, 49,000. Supposing that each beet will weigh 1 pound, this will give a yield of $24\frac{1}{2}$ tons per acre. The above conditions may represent a fair average beet field under favorable conditions, although it must be admitted that the average yield of beet fields does not reach so high a figure. If, however, there is a complete stand of the plant, so that every space is occupied, with a fair soil, properly prepared and cultivated and supplied with a proper fertilizer, the above yield can be secured. In every case, however, an attempt should be made to plant the beets close enough together to secure a matured plant, after the separation of the head and tops, weighing about 1 pound. This is found to be the size which best secures a high content of sugar with a large yield of roots, and therefore represents conditions most favorable both to the farmer and manufacturer.

IMPLEMENTS FOR CULTIVATION OF SUGAR-BEETS.

Any ordinary plow may be used for preparing the land for sugar-beets, care being taken that the ground be evenly and completely broken and at an even depth. Instead of plowing to the depth of 12 to 15 inches in the first place, it is best to use the first plow to the depth of 9 or 10 inches, following with a subsoil-plow to the depth of 4 or 5 inches. A subsoil-plow suitable for this purpose is manufactured by the Moline Plow Company, of Moline, Ill., and its general character is shown in Fig. 13.

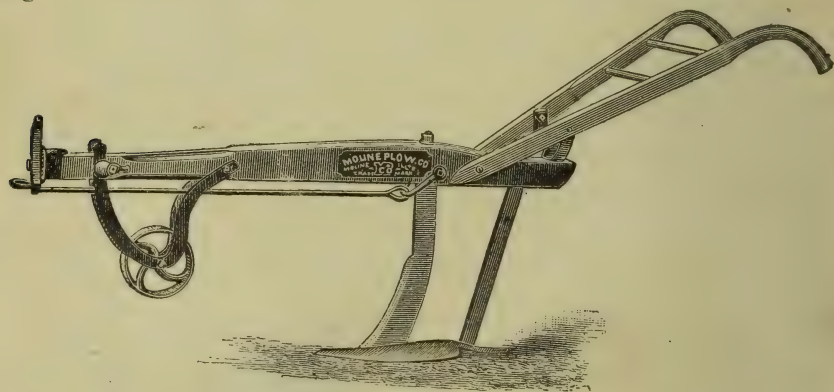


FIG. 13.—Subsoil-plow.

It is often convenient to have the plow and subsoil-plow combined in the same instrument, thus saving the labor of one man. So little subsoiling is done in this country that very few such implements are to be found in the market. A plow of this kind, largely employed in France, is manufactured by Bajac at Liancourt (Oise), and its general form is shown in figure 14.

The subsoil plow is removable, and when the instrument is to be used as an ordinary plow it can be taken off. In plowing with subsoil attachments care should be taken to make narrow furrows, so that

the whole subsoil may be loosened and not left in a series of trenches. In no case, in plowing for sugar beets, should the furrow be wider than the cutting capacity of the plow itself. Any good harrow can be used for reducing the plowed land to the proper tilth, and no description of this instrument will be necessary in this place.

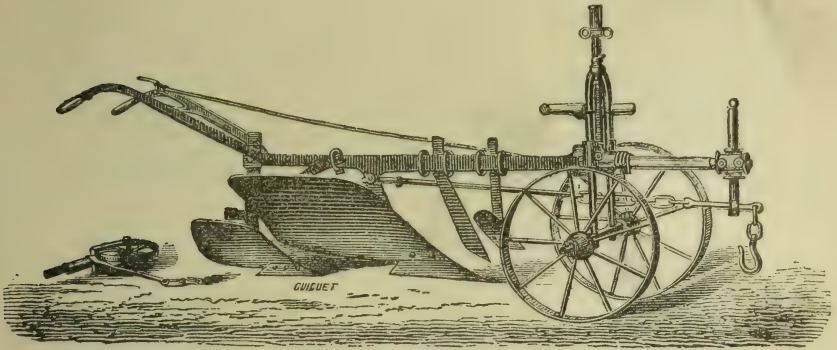


FIG. 14.—Subsoil-plow, attached to plow.

For planting the seed it is best, in small patches, to do it by hand, or by the implement represented by Fig. 12, but when large areas are to be sown in beet seed, power drills should be provided. A drill made by the Moline Plow Company for cotton seed can be easily adapted for use with beets. This is shown in Fig. 15.

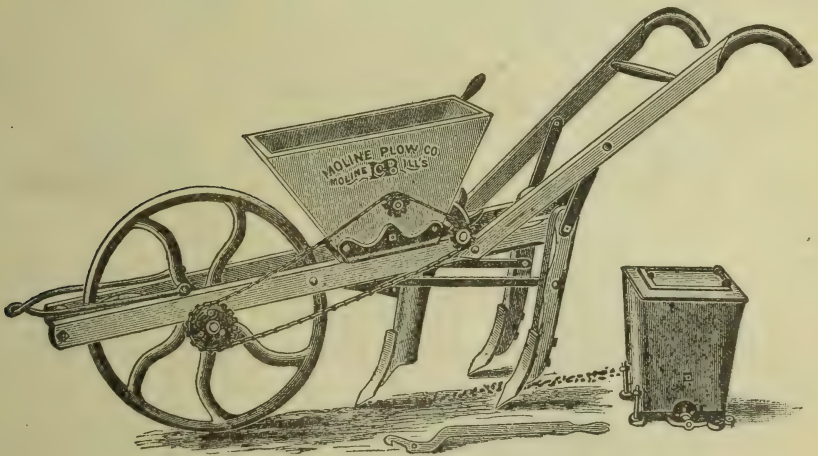


FIG. 15.

An ordinary drill for planting Indian corn can also be easily adjusted for planting beet seed. Great care, however, should be taken in drilling the beet seed not to cover it too deep, and all drills should be adjusted so that the average depth of the seed shall not be more than 1 inch.

CULTIVATION.

In addition to the hand-hoe, Fig. 16, for early cultivation, the horse-

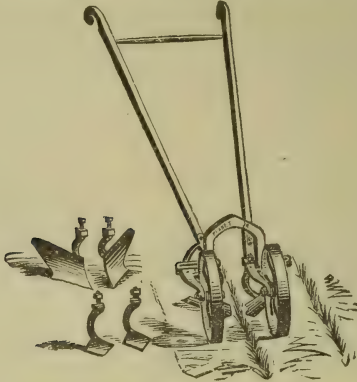


FIG. 16.

hoe manufactured by Bajac can be used with great advantage. Its general construction is shown in Fig 17.

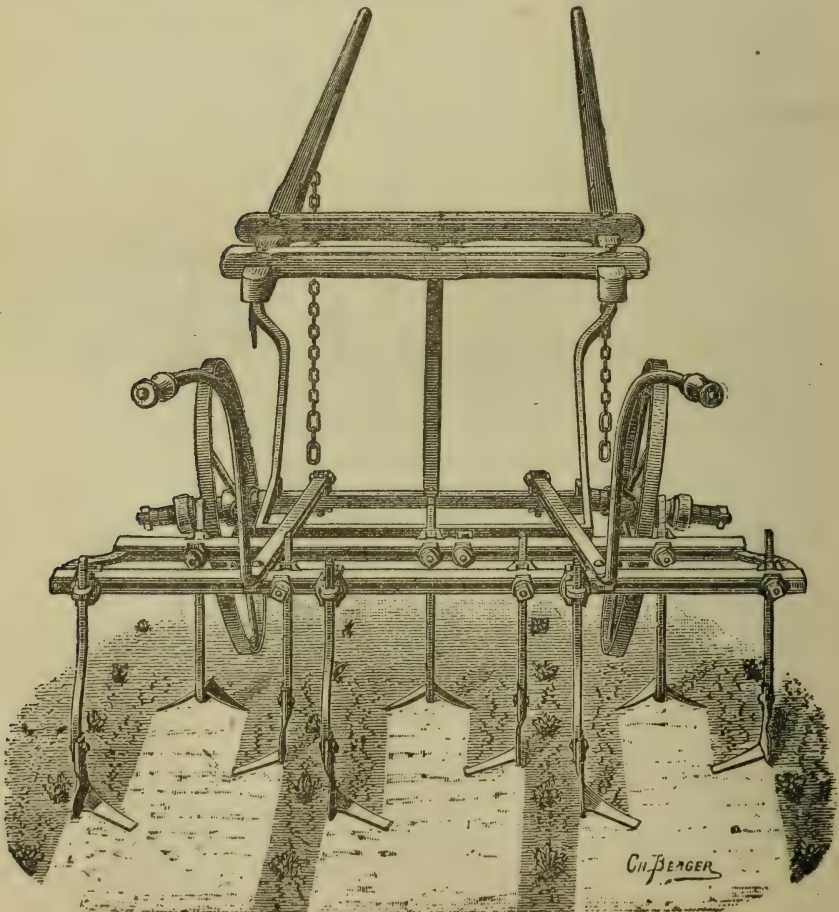


FIG. 17.—Horse-hoe for sugar beets,

Other forms of apparatus used in cultivating beets are shown in the following figures, 17 to 21, inclusive.*

Bertel's ridger, drill and cultivator.

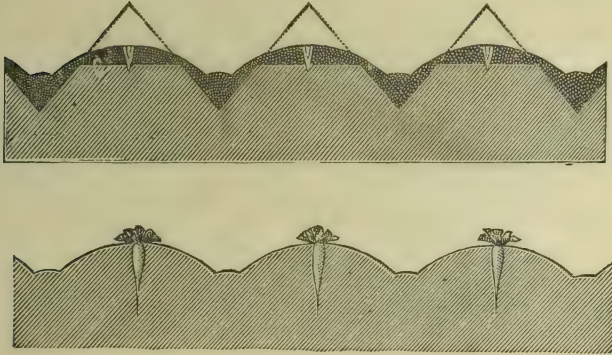


FIG. 18.—Ridges after passage of drill.

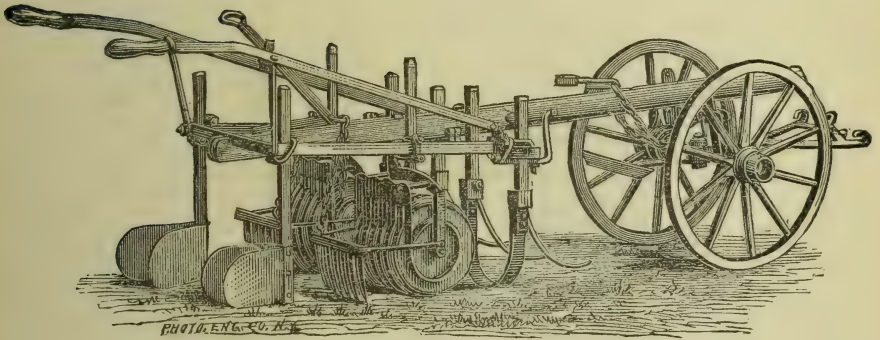


FIG. 19.—Cultivator for working between rows or ridges.

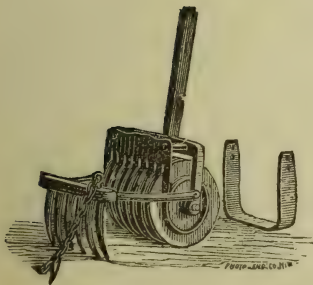


FIG.—20. Scarifiers and rollers for flat culture.

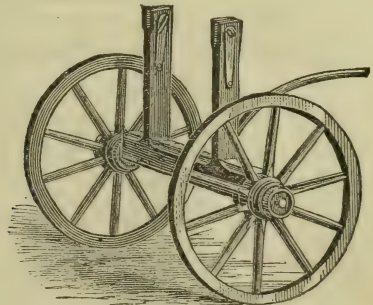


FIG.—21. Leader to cultivator.

* From McMurtrie's Special Report No. 23.

The hoes are arranged so as to cultivate three rows of beets at a time, and are so adjusted as to completely clean the spaces between the rows without throwing any of the soil upon the young plant itself. Inasmuch as each seed of the beet may give one, two, or three plants, form-

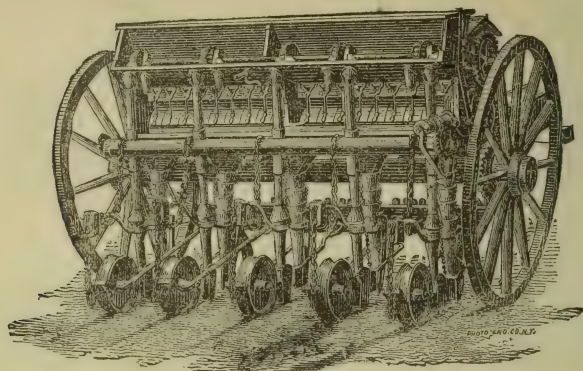


FIG. 22.—Combined beet-seed and fertilizer drill for flat culture.* (James Smyth & Sons, Peasenhall, Suffolk, England). The machine has a range of five hoes 18 inches apart, but the machines vary in number and interval of the hoes, and in price.—(Knight.)

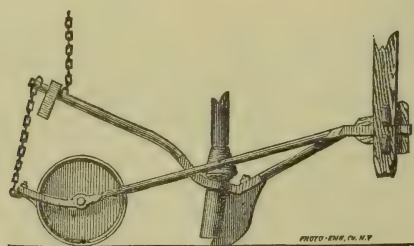


FIG. 23.—Detail of hoe and covering wheel.

ing clusters in the rows, it is necessary that the thinning should be done as carefully as possible without injuring the plants remaining in the soil. It is best that the planting should be close together so as to give a large excess of beets, since in case replanting is necessary it will be noticed that the replanted beets, are uniformly of poorer quality than those of the first planting, and if possible the surplus beet plants should be removed by a sharp-cutting hoe without touching the one which is to remain. In this way one healthy plant should be left from every 6 to 10 inches in the rows. When the beets begin to show the neck above ground, it is well to throw a little dirt against them so as to form a slight ridge. This can be done by a ridging hoe, such as is indicated in Fig. 24.

* From McMurtrie's special report No. 28.

This hoe, as well as the one mentioned previously, is made by Bajac.

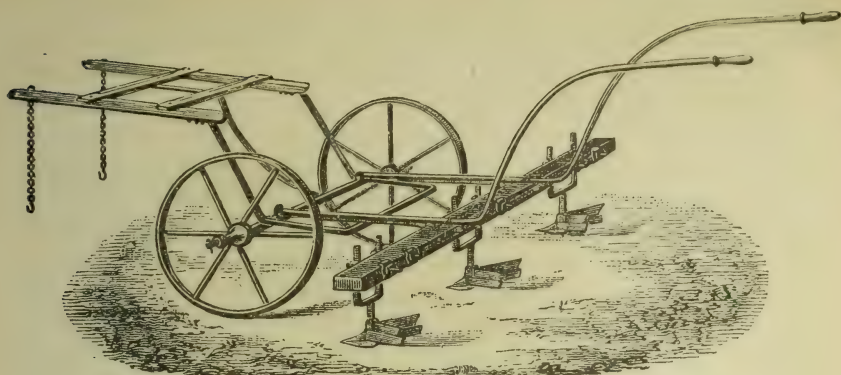


FIG. 24.—Ridging hoe for sugar-beets.

After the ridging is done it is recommended to go between each row with a subsoil plow of very narrow cut to the depth of 12 to 15 inches.

CULTIVATION.

Whatever kind of cultivator may be employed it will be found necessary to protect the young plants from being covered by dirt. Various kinds of shields may be used for this purpose, such as are often used in the plowing of young corn. Sometimes it is customary to cultivate the beets before they are up. For this purpose at the time of sowing a few grains of rye are placed in the furrow with the beet-seed. Rye, sprouting sooner than the beets, marks the rows so that the cultivator may be used as if the beets were already out of the ground. The cultivation should take place at least every two weeks, and oftener if the ground is very weedy, till the middle or the end of June. Unless some shield is used, as above indicated, for the young plants it will be found that many of them will be destroyed by the early cultivation, leaving large spaces unoccupied in the rows, thus giving a smaller yield, and permitting at least a portion of the beets in the fields to grow to an unusual size.

METHOD OF CULTIVATION USED AT ALVARADO, CAL.

The method of cultivation employed by the Alameda Sugar Company, of Alvarado, Cal., has been kindly sent to me by the president of the company, Mr. E. C. Burr, and is as follows:

“Plowing begins soon after the 1st of January and continues until late in the spring, varying according to circumstances of weather and soil. The lands are subjected to two plowings, the first about 8 inches deep and the second to the depth of 12 inches, seldom more, although it would be better in results. After plowing the lands are rolled to

break clods, then harrowed and planked with a rude contrivance made of boards.

Rude as it is, it is quite effectual in reducing the lumps and giving the surface a smooth appearance. The preparation of the soil is one of the chief factors for a good crop. The plowed lands are now allowed to stand for a short period, generally a week, until, as farmers say, "the under moisture comes to the surface," an expression which may mean the reverse, for intelligent farmers claim that the lower layer turned to the surface is too cold and damp to germinate the seed readily, and by letting it stand open to sun and air it becomes drier and warmer. After the resting period seeding begins with horse drills, in rows 15 inches apart, and eight rows to the machine, the seeds being dropped in an almost unbroken row in order to induce a good stand. The depth to which the seed is planted varies from one-half to 2 inches, but our instructions this year are to plant one-half inch deep only, as our observations last year showed a large percentage of ungerminated seed at the greater depth, owing probably to too low temperature. As soon as the plants form three or four leaves, that is, large enough to distinguish from weeds, they are thinned out to 4 inches apart in the rows and freed from weeds. In about sixteen to twenty days the second weeding and cultivating takes place. Last year the cultivation part by Chinese labor was a farce, but this year we have introduced some French implements in the shape of "extirpators" and scarifiers which we hope will free the farmer from the Chinese, and do the work more effectually. The "extirpateur" we imported from Mr. H. Amiot-Lemaire of Bresles, France, and which, acting similar to a harrow, is intended to loosen the soil to a depth of 8 inches. The scarifier, as its name implies, is to go between the rows and destroy the weeds. It is built like our cultivators, but with entirely different blades.

"Last year the cultivation was flat, but with the new implements there will be more of a tendency to ridges. The farmers use no fertilizers as yet, although they would be benefited thereby. Were this company raising its own beets, I should certainly insist on it. Yet the lands so far seem to show no deterioration. Last year the whole State suffered from drought and our crop was meager in consequence.

"The average number of plants per acre was 57,000. The average weight per root, topped, on the highlands near Centerville was 121 grams; near Alvarado, on lowlands, the weight, under same conditions, was 307 grams. There is no agreement between the number of roots per acre and the weight. The estimate was carefully made when the first weeding and thinning was done, for roots per acre, and the weights were determined at the factory from every load delivered. In July, near Centerville, the roots ceased growing and we worked hundreds of tons of beets no larger than a cigar. In some places the yield was not over two tons per acre. Of course, under these circumstances, many roots did not mature.

"The methods of farming here must be altered to a very great extent, but it is very difficult to convince the farmers and will take time to effect. We hope during the current year to make some improvement, and shall continue our system of obtaining data. Two men are constantly in the field (one a chemist) from the time the first seed is given out until the crop has matured, and they survey each man's plot, estimate the number of roots per acre, obtain weights weekly of beets with and without leaves, and make weekly tests of sucrose, non-sugar, quotient, etc., from each man's parcel. They also note method of cultivation, condition of crop, etc.

"The sowing begins toward the end of March and continues, working from the highlands to the lowlands, until the middle of May.

"The crop matures about August 15, and is all at the factory by December 1, our storage capacity being for about 6,000 tons only. We tried some experiments with beets in cold storage, but the figures are not before me. One test is worth noticing. We tested beets which had been continuously overflowed from December 1 to March 1 and found them to contain 14 per cent. sucrose, with a quotient of 84 per cent."

DISTANCE AT WHICH SUGAR-BEETS SHOULD BE PLANTED.

Formerly the author had recommended that beets should be planted so that there should be about 10 plants to the square meter. Since, however, the change of law in regard to the taxation of beets requires that they should be grown with great saccharine richness he recommends that they be planted so as to have from 15 to 20 plants per square meter. In this way a beet of great richness can be secured, while the quantity produced per hectare will remain about the same as when only 10 plants per square meter were cultivated.*

METHODS OF CULTIVATION IN BOHEMIA.

The methods of cultivation used in Bohemia are described by Commercial Agent Howes, as follows:†

"PREPARATION OF THE LAND.

"The sugar-beet needs well-cultivated land. First, a surface loose and fine, which allows the air to enter and facilitates germinating and swelling; second, deep, loose, uniform soil, because the beet should develop a slender root without side rootlets. Both can be obtained only by good cultivation. Cultivation differs according to the soil.

* A. Ladureau, *La Sucrerie Indigène*, Vol. 33, No. 23, p. 582.

† Consular Report pp. 248 et seq.

"The following suggestions are of value: Loosen the subsoil without bringing it to the surface. If the subsoil be not good, this is doubly important. The depth should be from 30 to 40 centimeters, and a plow similar to that shown in Fig. 25 should be used.

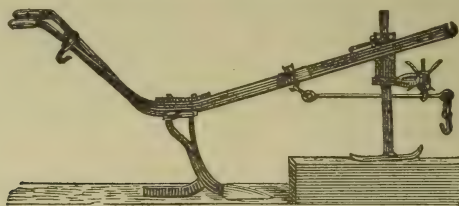


FIG. 25.

"To begin deep plowing, 30 centimeters will be deep enough. After several years it may be made 40 centimeters, but should be deepened only gradually, because, if too much dead soil comes up, the land is ruined for at least one year. Deep plowing should always be done before winter, so that the frost has time to work on the soil.

"*Steam plowing.*—By the introduction of the steam-plow an implement was put in the hands of the farmer, the work of which can not be equaled. The reasons why the steam-plow works so well are—

"(1) By the speed with which it operates the soil is well mixed and pulverized.

"(2) The depth of all the furrows is the same.

"(3) It plows to any depth, especially in heavy soils which would require a large number of animals. Generally the soil is loosened to a depth of 35 to 50 centimeters, and the plants are enabled to take nourishment from a larger quantity of soil.

"(4) In dry seasons soils plowed by steam retain longer their humidity. In wet seasons the water descends quicker to the subsoil. The steam-plow increases the crop and renders it certain.

"(5) The animals leave foot-prints (four oxen make about three hundred and sixty thousand in plowing 1 hectare), and therefore cause a not unimportant loss.

"(6) It is possible to work in spring and fall, when with animals it would be impossible.

"(7) A large number of animals can thus be used for other purposes.

"If we consider that with a steam-plow 3 hectares can be plowed in a day, while with a common plow one-third of a hectare can be gone over, then nine common plows are needed to do the work of one steam-plow; and, as four oxen are needed for each plow, thirty-six oxen would be employed, and, as they should be used only half a day, seventy-two oxen would be required, and their work is not equal to that of one steam-plow.

"The excellent work of the steam-plow can increase the crop of beets from 4,000 to 5,000 kilograms per hectare. The cost of plowing by

steam is between \$11 and \$16 per hectare for a depth of 32 to 40 centimeters.

“Deep plowing can be done in such a way that two plows go one after the other, the first cutting 15 to 20 centimeters deep and the second 10 to 18 centimeters.

“Another way to loosen the deeper soil is as follows: The land is plowed from 15 to 20 centimeters, and laborers then spade up the deeper soil from 20 to 24 centimeters, the undersoil being scattered over the surface. This method is expensive, but produces very good results.

“Still another way to procure most of the advantages of deep plowing, and one which is generally used on very heavy soil or on lands exposed to inundations, which consequently dry at a late period, is to form ridges.

“This is done in the following manner: The land is plowed in the fall in such a way as to form a ridge. For this purpose a hill plow is used, or a machine invented by Dr. Bärtel and called a ‘ridge former.’

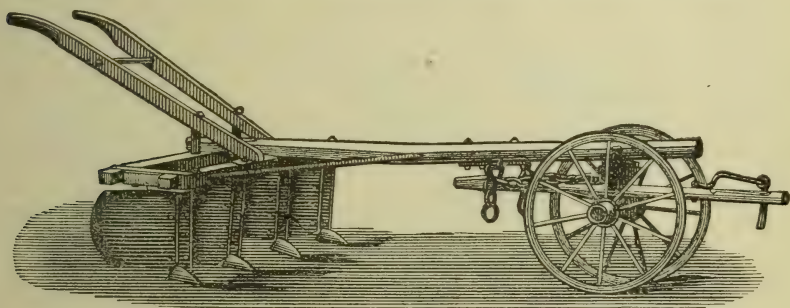


FIG. 26.

“In spring these ridges are split, and thus new ridges are formed. These must be rolled to an even surface.

“The advantages of preparing the land in this way are: The water gathers in the furrows and runs off; the soil in the ridge is always in a good condition and the air can penetrate it.

“If grain has been grown on land about to be planted in beets the preparation goes on in the following way: The stubble is plowed as

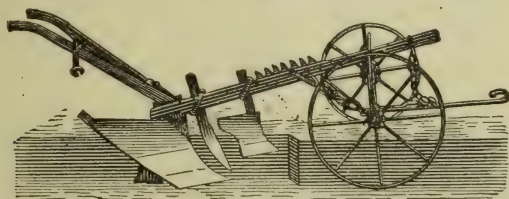


FIG. 27.

soon as possible to a depth of 5 to 8 centimeters. For this work gang plows, as shown in Fig. 27, are used.

"As soon as weeds come up the land is harrowed and rolled. Before winter the deep furrow is plowed, and, if stable manure is used, it should be applied before the middle of November. In such cases only a moderately deep furrow is needed, because, as before remarked, the manure thus decomposes better.

"The land remains in this state during the winter, and is therefore exposed to the influence of frost, rain, etc. In spring it is ready for the beets. Then, as soon as possible, it should be harrowed. The harrows used are, if the land is crusted, 'The Extirpator,' or, if necessary, it must be plowed 15 centimeters deep. Then the "Acme" harrow is used.

"If sugar-beets follow beets, potatoes, or corn, the land is simply plowed before winter.

"Before planting all land should be rolled.

"PLANTING.

"The time of planting influences the crop in a high degree.

"It is shown that in a warm, dry season the crop of an early planting is larger than in a cold, humid season. The time of planting is the middle of spring, with a temperature of from 9° to 12° C. (48° to 54° F.) Early planting begins with April and lasts until the end of that month; late planting is in May. In general, early planting is to be preferred, because the danger from frost is not so great as that of drought. It should always be remembered that the seeds should be put in a soil warm enough to germinate in six or eight days, not twelve to sixteen days, as is the case in cold, humid soil.

"*Distance apart.*—This has a great influence on the crop and the quality of the beet. The experiments of Vilmorin show that the largest crop will be grown if the beets be planted comparatively near together. If the distance increases, the proportion of leaves increases. The lighter and poorer the soil the further must the beets be planted apart, and experiments show that this influence is greater than that due to manuring, or even the choice of the variety. Distances vary from 30 to 50 centimeters from row to row, and from 10 to 25 centimeters in the row.

"*Depth for planting.*—The seeds need only a very light covering—2 to 3 centimeters is the right depth. If part of the seeds are not covered at all, it does not cause so much damage as if they are covered too deeply.

"CULTIVATION.

"From the time of planting up to that of harvesting the following suggestions should be observed: As soon as the sowing is done the roller must be used, because in pressing the surface the humidity, which is very necessary for the process of germinating, is drawn by capillary attraction out of the deeper soil, and the surface is thus kept moist. The roller may be smooth or have rings; the latter is better, because it makes the surface of the land rough, and therefore a heavy rain can

not form a crust. If, after sowing, a crust covers the field, the ring-roller is the best implement for breaking it, and after this a light harrow is recommended. Thus is the soil loosened, the air can enter, and germinating and growing are facilitated. When the plants have grown so that the rows are visible, hoeing must be done, and the earlier the better, not only because the weeds are destroyed, but also because the plants need a loosened soil. The oftener the plants are hoed the better will be the crop as regards quantity and quality. Indeed, quantity and a high sugar percentage can only be obtained by hoeing. The first hoeing must be only superficial, that all the weeds are thrown on the surface to dry, and care must be taken that no soil covers the young plants. The hoeing should be done even if the land be dry, as hoeing prevents the evaporation of the water from the deeper soil. If laborers can be had, it is preferable to first hoe by hand in such a way that only the soil about 50 centimeters distant from the beet is hoed and the soil between the rows is untouched. This is then hoed with the cultivator. If hoeing must be done by horse-power, the cultivator shown in Fig. 28 is used.

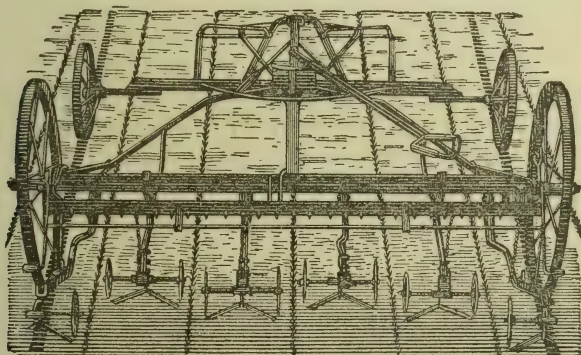


FIG. 28.

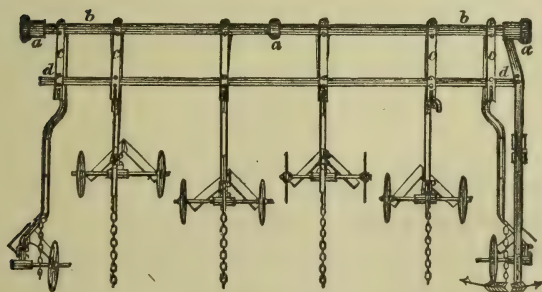


FIG. 29.—View from above of same machine.

“After the hoeing comes thinning out. This must be done as early as possible, and generally, plants sowed by the Dippel machine must be

thinned out earlier than those planted by the drill, the reason being that the latter have more light and air than the former. It is practical to thin out when the plants have three or four leaves. The root is then as thick as a straw, and the whole plant has a length of 8 to 10 centimeters.

"If planted with a drill, the work of cultivating can be done in two ways:

"(1) The field is crossed with the cultivator at right angles to the rows, and the knives are set so that they leave about 2.5 centimeters on each side of the beet untouched. Of the plants which remain in this space the weakest are removed by hand.

"(2) The whole work is done by hand. By means of hoes the laborers remove the superfluous plants, leaving spaces about 20 to 25 centimeters between. Children are employed here for this work, as they can best get down to it.

"Cutting the leaves off is not sufficient, as the leaves grow again; or, if not, the plant becomes a harbor for insects. One person can thin out one-ninth to one-eighth of an acre a day. After thinning, hoeing by hand should follow immediately to loosen the soil around the plants; then, between the rows should be hoed, and the time this should be done depends upon the weeds and the soil. As a rule, the intervals should not be more than a fortnight. A fourth, and possibly a fifth, hoeing would increase the crop. Of course, hoeing can not be done when the plants are large enough to be damaged.

"Hilling up now follows. This must be done because, by covering the beets with soil, it prevents the heads from growing out, and therefore this part of the root, which is of no value to the manufacturer, as it contains little sugar, is lessened. Water can run off and evaporate better, and the soil will not become incrustated. In heavy soils this is a very important point. The time for hilling up is important, as if this is done too early the plants are buried, and if too late the leaves are damaged. Hilling up can only be done when the soil is in good condition, *i. e.*, neither too wet nor too dry. For this can be used a plow with a single share, or that already shown in Fig. 29. On small farms it is usually done by hand.

"HARVESTING.

"This is done when the beets are ripe, *i. e.*, when growing stops and all the products of the leaves go to the root, where they are deposited. In Bohemia beets ripen from the end of September to the middle of October.

"*Signs of ripeness.*—The leaves become yellowish green, fall and form a kind of a wreath around the plant. The middle leaves, so-called "heart leaves," also of a yellowish green, do not fall.

"Harvesting should not be too early, as the loss occasioned thereby

may amount to as much as 2 per cent. Of course harvesting must take place before heavy frost, though the beet can stand frost from 3° to 4° C. (24° to 27° F.). If early frosts should come, it is best to let the beets thaw in the soil, as the loss will be thus lessened.

"How harvesting is done.—(1) By hand. To each man is apportioned a certain tract of land, which he works by contract. The soil around the plant is loosened, and then the plant is drawn from the ground by hand. Work with the fork would be easier, but might injure the beet.

(2) By team. A subsoil-plow is used, which should be set for a depth of 35 centimeters. A still better implement is the beet-lifter, shown in Fig. 30. This machine can be worked by a boy, and also does not injure the plants which are left loosely standing upright in their places, where they are better protected against sudden rain or frost than if lying upon the ground. As work can be done much faster with the lifter than by hand, this machine will no doubt be of much use in the United States.

"Cutting off the heads.—The green heads must now be cut off, as they are of no use. This is done in the field, and here it is the work of women and girls, who accomplish their work rapidly, using sharp knives. About 1 to 2 centimeters of the beet is removed.

"Piling up the beets.—This is necessary, as it is impossible to immediately transport an entire crop to the factory, and they must be protected from rot and frost. Perhaps the best plan is that recommended by Knauer, especially if the beets must remain a long time on the field. A ditch 1 foot deep and 6 feet wide is dug, and of the required length. Beets are then piled up with roots toward the center for a height of 1 foot, and covered with 6 inches of soil. Then another layer of beets, covered also, is added, and then another, until the pile, tapering, is of the shape of a prism. If the soil is very dry, water should be applied. Beets so buried will keep six or seven months with little loss.

"It is best to grow only one crop in four or five years on a single field, as otherwise the soil will be exhausted and insects and parasites increase, so that great losses would occur. Beets should follow grain or barley, and after the beet the best crop to plant is barley."

HARVESTING THE BEETS.

The beets may be harvested either by hand with a hoe, spade, or fork, or by simply pulling them from the ground, or by a harvester drawn by horse power. Some advantages are claimed for each method. If the harvesting be carried on by hand, care should be taken that the instrument used should not strike the beet, since it is certain that every time the beet is punctured or bruised a certain loss in sugar will ensue unless it is immediately worked. It is estimated that in harvesting by

hand each beet, on an average, will lose from 15 to 20 grams of its weight, or very nearly a ton per acre. For the Bajac harvester figured it is claimed that the beets are entirely loosened from their position, so they can be easily removed by hand with much less danger of being bruised or broken than any other method of harvesting. It is also estimated that by mechanical harvesting a more complete removal of the beets from the soil is secured, since when the harvesting is done by hand many roots are left unnoticed in the soil. According to some estimates from 1 to 3 tons of beets may be left per acre when the harvesting is done by hand. It is further claimed that by the mechanical method of harvesting the beet, being neither bruised nor punctured, is more readily handled for the purpose of preservation, without being exposed to the least source of loss.

It is probable that in this country the mechanical method of harvesting beets will be almost the sole one employed for all commercial pur-

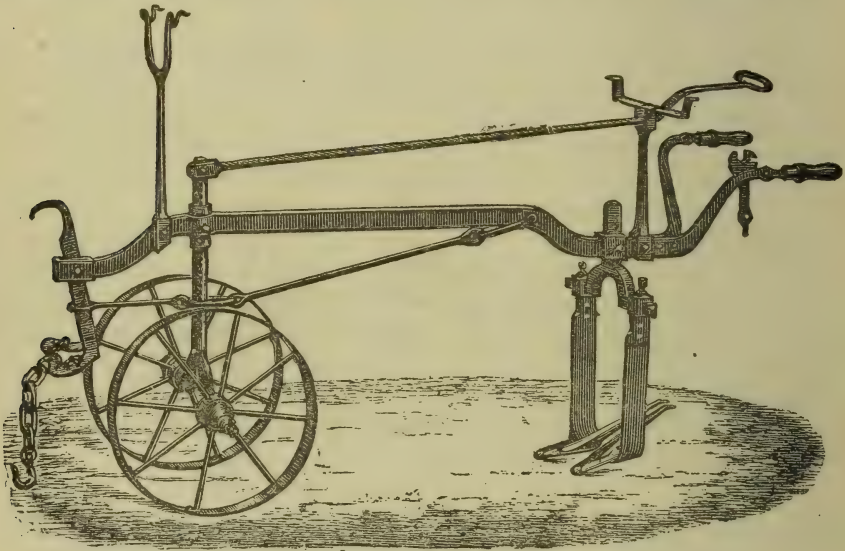


FIG. 30.—Beet harvester for one row.

poses; but meanwhile, where beets are grown only in small quantities and before the introduction of the proper machines for harvesting, it is probable that harvesting by hand will be more common, especially for small plots.

A note has already been given in regard to the time of harvesting, which should begin as soon as the beets are thoroughly matured and before they have an opportunity to take a second growth or be exposed to freezing temperature. In some places in California, as has already been stated, the harvesting begins as early as the middle of August, while in the Northern, Central, and Eastern States it had best be postponed at least until the middle of September, and perhaps better until the middle of October.

Harvesting the beets is best done by implements devised for that purpose, two of which, made by Bajac, are shown in Figs. 30 and 31.

The first one is a machine for harvesting a single row at a time and the second one indicates the beets caught in the prongs of the apparatus arranged for two rows. Harvesters are also built to take three rows of beets at a time.

Mr. Lewis S. Ware, editor of the "Sugar Beet," who attended the Universal Exposition in Paris in 1889 for the purpose of making a study of the sugar-beet exposition at that point, makes the following remarks in regard to harvesting:*

"Beets, like other plants, require a certain number of degrees of heat for their complete maturity. Just when this period is reached is difficult to determine; one fact, however, remains certain, that whatever the theories are respecting outer signs they can not possibly hold good for all conditions of weather, climate, etc. That the leaves are brown

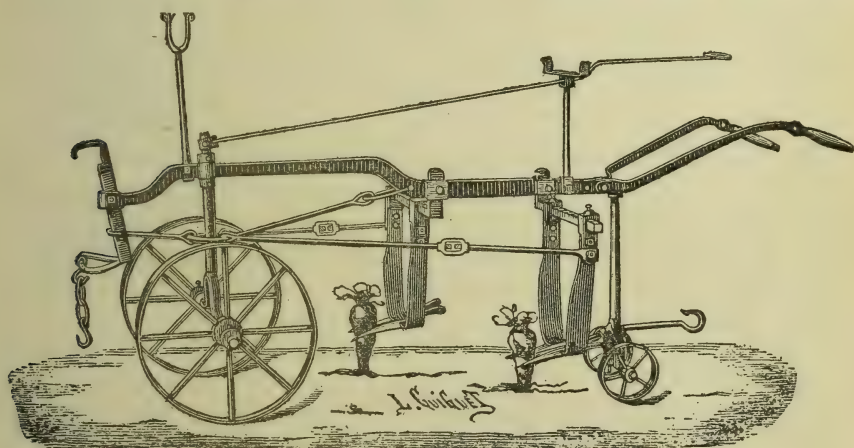


FIG. 31.—Beet harvester for two rows.

or covered with characteristic spots or other indications when the greater purity of juice has been reached must remain very empirical. Many manufacturers have suffered from early harvesting where farmers have depended upon outer signs of the general appearance of the field, such as a yellow or green color, etc. Some agronomists maintain that there exists a proportion between the weight of the leaves and the root, the latter being almost a constant at 65 and 35 for the leaves in a weight of 100 pounds. This can not be a constant, as it varies with the variety of beet. Others contend that a proportion of this kind is more reliable than any system of analysis.

"In France the harvesting occurs at the end of September, and during October cold weather frequently commences. The farmer too frequently considers his own interest, and neglects that of the manufact-

* "Sugar Beet," No. 4, vol. 10, p. 49.

urer; if he leaves the beet in the ground for a considerable period it is solely with the hope that the weight may increase; when this ceases, from his point of view, the roots should be harvested.

"There are, however, cases where experience teaches that certain portions of the field should be harvested earlier than other parts; but unfortunately it frequently happens that hands are then secured with difficulty, and the farmer is unable to furnish the roots at the factory in the best possible condition. One plantation may be in the most desirable condition, while another may not reach the necessary maturity for several weeks afterwards. It necessarily follows, that if the entire crop is harvested at once, it will frequently result in a considerable loss to the manufacturer, and may represent 1 per cent. difference in the yield.

"On small areas special harvesting spades are used, or frequently a sort of fork. The latter has evidently the disadvantage of bruising the root, resulting in a decrease in sugar percentage. Whatever be the method adopted, the roots when taken from the ground are shaken to rid them of adhering particles; frequently the necks are then sliced off, and the roots covered with leaves to protect them from the sun, rain, etc. Many farmers simply make piles of their roots, covering the same with thin layers of earth, awaiting the time for hauling either to the factory or the silos. It has been frequently noticed that there results an increase in the sugar percentage of the roots during the several days they remain in the piles. All the hand methods of harvesting have one important objection, viz, the difficulty of obtaining the full labor of men or women, owing to the fatiguing nature of the task.

"Viallette recommends harvesting with a plow, the coulter being taken off. Two horses are required and the plow is run alongside of the row, about 2 centimeters beyond the beet, throwing the earth to one side; children follow the plow, and collect the roots. The objection to this method is, the fields are always in bad condition after a rain and carting from them is almost impossible. The cost of harvesting with the plow is \$7.40 per hectare.

"It has not been many years since the Bajac beet harvester was introduced to the public, and since then it has undergone but few modifications as regards the general working. It is constructed entirely of steel, and is very light and simple in its mechanical working and arrangement. To the fore wheels is attached a well-balanced vertical bar, with a series of horizontal holes, into which is run the pin holding the horizontal shaft for the support of the harvesting blades.

"The blades are made of the very best steel, and are so constructed as to offer but little traction during their working; their penetration in the soil hardly affects the upper surface. The slight slant of the blades, when in contact with a beet, forces it upward, and the operation is completed by a peculiar vibration given, caused by a portion of the blade having an elliptical section. As soon as the implement moves

forward, the loosened roots fall back into their respective holes. Under these circumstances, there can be an interval of several days before collecting them for the factory. During this period, as they are not exposed to the open air, there is no danger of second growth produced by rain, etc. The working of the Bajac harvester requires but little experience, and at a few minutes' notice hands are said to be able to handle it.

"The direction of the harvester is determined by a lever within easy reach of the conductor. The depth of the harvesting blades may be regulated according to requirements. It is very evident that the work of this machine is preferable to hand harvesting; not only is it better done, but the cost is very much diminished, and need not be more than \$1 an acre, regardless of the distance between rows. Practical experience appears to demonstrate that the saving is about 30 per cent. of the amount harvested. Small, adhering roots not being removed, the beets are in a perfect condition when delivered at the factory.

"Before mentioning other advantages of the implement under consideration, it is interesting to give some even more recent types of the Bajac harvester.

"Owing to the success obtained with this machine it has been suggested that a two or three line implement might render excellent service; both of such are on exhibition. The general arrangement is the same as with the one-line description.

"The work in both cases is very satisfactory, and 4 acres with the two-line implement and 5 acres with the three-line type may be harvested in a day of ten hours. In the latter case the traction is considerable, and requires at least four horses. If, in certain cases, beets are harvested rapidly, the operation may result in considerable profit to all interested. Interviews and conversations with farmers have convinced the writer that the Bajac harvester is the best in existence. Beets over 1½ feet in length are extracted from the soil, which could not be accomplished by any previous appliances. The fact is, we have seen with their tip ends, so to speak, a distance of nearly 3 feet from the neck, taken from the soil after these harvesters had finished their work. When we consider that the richest portion of a beet is that which was previously left in the ground after harvesting, we have no difficulty in realizing the excellent services these implements are destined to render.

"Caudelier's beet harvester appears to be very original in design, and was in use for the first time in 1888. Its work is very satisfactory, and certainly much more economical than could be done by hand. The arrangement of its several parts is calculated for the best results.

"The necessary traction to work this implement is said to be very slight, two horses, however, are required. A fact not to be disputed

is, that the soil is very slightly disturbed; the fore wheels determine the direction of the work and support the working parts. The depth of penetration may be regulated by a screw, while the coulter, placed in front of the harvesting device, opens the soil. This is said to diminish the resistance the harvesting tool and its flat slanting support would offer. The circular disk between the fore wheels slices off the leaves as the row of beets is harvested. Under these circumstances, as is frequently the case, they do not collect against the coulter or form an obstacle difficult to surmount.

“Caudelier had on exhibition another type of harvester much simpler in its construction than the foregoing. The arrangement of fore wheels and attachments permit the slanting of the implement in any direction. In the working of this harvester the beet is scarcely touched, the blade passing under the root without bruising the same.”

REMOVING THE NECK OF THE BEET.

The upper part of the beet bearing the stems of the leaves and the part which is most exposed to the sun and light is known as the neck. Before the beets are manufactured it is necessary to remove this neck, both on account of the poor quality of sugar juice which it contains and on account of the large amount of mineral salts found therein. Two methods of procedure are followed. In one case the necks are removed at the time of harvesting, and before the beets are siloed. This method saves one handling of the beets and prepares them at once for washing and manufacture. The other method consists in siloing the beets before the removal of the necks, and postponing this process until they are ready for manufacture. This method is preferred for the following reasons:

When the necks of the beets are cut the juices of the plant escape, including a portion of the sugar, and fermentation is easily set up in the silos. It is therefore probable, on the whole, the beets will be preserved much better in the silos without having the necks removed. According to Bajac (*Bulletin de L'Association des Chimistes*, April, 1890), harvesting should take place before the beets lose their vigor, and in place of removing the necks and sending the beets at once to the factory, or silo, they should be placed in small piles, together with their leaves, of from 70 to 80 centimeters in diameter and of equal height. These piles should be quite conical and with the leaves turned out. The summit should be covered very carefully, in order that the water and frost may not penetrate it. In place of separate piles, rows of such beets could be established along the length of the field, and being left thus for a fortnight, the beet would finish its maturation with its leaves still attached to it. It would lose scarcely anything in weight, and it would gain in density and, probably, in sugar.

In regard to density, experience has shown that beets harvested on the 20th of September and showing at that time a juice of 1.072 sp. gr. which were preserved with their leaves as above mentioned, gained in six days .006 in density. Experiments carried on for a month from week to week upon beets from the same field, some having the necks cut and the others preserved with their leaves, showed in each instance an increase in density, while the decrease in weight of the whole beet was most sensibly marked in those in which the neck was cut off. Some of these beets exposed to rain on the 20th of November showed some curious phenomena. Those in which the neck was cut had lost .003 in density, while those with their leaves remaining had lost only from .001 to .005. Beets with the necks cut which had been kept for a long time were found almost dried out, while those in which the leaves had not been removed were but little affected.

HARVEST AND PRESERVATION OF THE BEETS.*

“If circumstances of labor, commencement of manufacture, weather, etc., allow, the beets should be gathered at the time when their outward appearance indicates their maturity; that is when the bright green of the leaves gives place to a lighter and more yellowish color and the older leaves wither and fall off. This is a sign that an arrest of the development has commenced and beets gathered then are best adapted for preservation and manufacture even though they may not have the highest sugar content. Beets which are harvested a short time before this period ripen somewhat afterwards in the silo, but generally do not keep so well.

“When the beets are gathered the leaves are cut off and they are immediately covered with earth in small heaps. With beets that are not to be kept very long it is best to cut off only so much of the head as may be necessary to remove the leaves so that they hang together. If it is desired to remove more of the crown it is better to do it in the factory immediately before the beets are worked up. Only at the commencement of the campaign when the beets are taken directly from the field is it advisable to cut off at once all that is necessary. Generally the beets that have been cut close show no tendency whatever to sprout, that is to show leaves in the silo. But their not sprouting is a sign of the cessation of all vegetable life and is generally accompanied by an undesirable change known as “hardening” in the juice, which is more injurious in the manufacture than the development of sprouts, and which latter, if it has not progressed too far, is preferred by the manufacturer.

“Various forms of plows are in extensive use for harvesting the beets; they are indispensable where hand-labor is scarce. They simply loosen the beets in the ground so that they may easily be drawn out, and do not injure the roots.

* Stammer, *Op. Cit.*, pp. 206 et seq.

"The preservation of such beets as are to be worked up during a season extending over several months demands the greatest care and attention to the climatic conditions. They must be protected from frost, which would burst the plant-cells of the beets and cause them to spoil rapidly after being thawed out. Moreover, too much evaporation of the water must be guarded against, as this produces a wilting of the beet, which would have the effect eventually of injuring the juice and the keeping qualities of the roots. Finally, too large piles of beets produces an elevation of temperature which heats them, and the spoiling of the beets follows in consequence. From these requirements it may be laid down as a rule, at least for the climate of Northern Germany, that beets should be placed in heaps or silos whose height and breadth are small enough to prevent the development of heat, and these should be immediately covered with a layer of earth, which should be sufficiently increased from time to time so that frost can not reach the beets. The layer of earth also affords protection against too much sprouting or wilting in consequence of too much warmth. The proper treatment varies somewhat in consequence of differences in climate and peculiarities of soil, but the following general directions may be given as of universal application.

"The beets should not be allowed to lie and wilt after harvesting, but covered as soon as possible. The silos, made as small as it is safe to make them, should point north and south.

"The use of straw is to be avoided except as a temporary protection against wind, sun, and frost, and should then be replaced with earth as soon as possible. Large beets should be preserved in small silos; with small beets the silos may be larger.

"Care must be taken not to damage the beets in putting them away, and injured roots should be carefully picked out. As a winter covering, 3 feet of earth is given in north Germany, though the last foot is not added at once. To facilitate their removal the piles should be arranged lengthwise along the driveways.

"For long keeping the top of the silo is generally roof-shaped, sometimes rounded off; the bottom is made either on the surface or slightly below it. In some cases such a form is chosen as gives a right-angled cross-section. There is nothing to show that the form of the silo or the nature of the soil exerts any influence on the preservation of the beets. The size of the silos used varies, and especially according to their situation, whether they are placed in the fields or near the factory. In the east of Germany large silos prevail, in the west small ones seem to be preferred. Breadth and depth vary less than the length; the breadth from $4\frac{1}{2}$ to $6\frac{1}{2}$ feet, the depth from 3 to 6 feet, seldom over 6, and only in a few instances less than 3. Where the silos are sunk below the surface it is generally 1 to $1\frac{1}{2}$ feet, seldom less. The quantity of beets that can be placed in a silo depends principally upon its length, and varies all the way from 6 or 7 tons up to 25 or 50 and more. When

placed in the field generally each acre or half acre has its special silo. Generally the contents of the silo are given in running yards of the length of the silo, and are usually about 1 to 2 tons per yard. Where the beets are heaped up according to the Belgian method, the piles hold very considerable amounts, even up to 1,200 tons.

"The covering is done with loose soil packed closely at the bottom, but being less dense toward the top. In the first weeks the top is left open, or very lightly covered, and heaped up when it becomes colder. The thickness of the covering varies from 1 to 3 feet, the latter thickness not being found very generally in the east. The use is sometimes made of other materials, for example, straw, etc. A thin layer of straw is covered over with earth, except at the top of the ridge. Some spread a layer of straw below the beets. It is generally accepted that in the silo a loss of sugar of about 1 per cent. takes place.

"A special method of siloing consists in leaving openings in the earth covering at the sides of the silo to keep the temperature low inside. The objection to this is that the beets quickly wilt around these openings, and that they can not be closed quick enough to provide against a sudden fall of temperature. Some places and climate require especial precautions.

"Babrinky has formulated the following rules for silos in southern Russia, based on many years of observation and experiment:

"(1) No beet should be further than 1 meter from fresh air.

"(2) For every cubic meter of beets there should be 30 square decimeters of evaporating surface.

"(3) The air in preserving cellars should be daily renewed if it be above 40° F. in temperature.

"(4) Beets do not lose more than 10 to 12 per cent. of their weight by evaporation.

"(5) If the beets are wilted on harvesting they should be moistened with water, and a large number of ventilating canals be built in the silos or cellars.

"According to Walkhoff, in southern Russia the beets are entirely buried in the ground, in a canal with steep, sloping walls. The bottom is covered with a sort of a grate of firewood, on top of which the beets are piled up to within a few inches of the surface of the earth. In the center on top is laid a triangular-shaped wooden gutter to increase the amount of evaporating surface. The whole then receives a covering of straw, which is increased or diminished in thickness according to the temperature indicated by the thermometer inserted. A sort of ventilation is accomplished by canals at the side leading outward, so that at night the cold air may be permitted to enter, while during the warmth of the day they are closed.

"Preservation in cellars is also much used in Russia, according to Walkhoff. These are built to project but slightly above the surface of the ground with their roofs, which are covered with earth. The bottoms

are covered with interlaced twigs, and the layer of beets is about 3 feet thick. Ventilation is secured by air-passages in the sides and roof. This method is rather more expensive, but the preservation is better insured.

“It has long been a desideration, so far unfulfilled, to find some means whereby the beets might be protected, on the one hand from the consequences of overheating and on the other from freezing, as well as from too rapid sprouting and from rotting; that is to say, in a good sound condition and without loss of sugar, for some length of time. On account of this not being yet attained, the tendency is to shorten the working season and to increase the quantity worked each day. The discussion of this question and the proper limits to set is of little advantage. It is to be hoped that more attention will be paid to observations on the changes undergone in the silo, upon which improvements in the methods used may be based.”

SILOS AND CELLARS.

The following illustrations of silos and cellars are taken from McMurtrie's Report 28. In California silos are not required, and the beets may be preserved in large heaps as shown in Fig. 43:

Preserving trench (Basset).

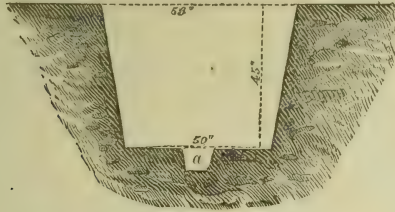


FIG. 32.—Trench open; *a*, drain trench.

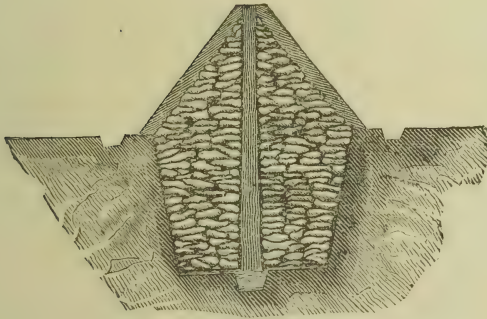


FIG. 33.—Trench filled, with ventilating shaft arranged.

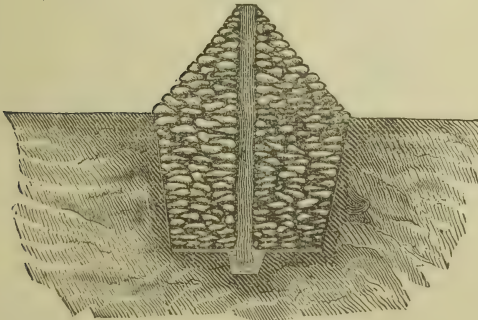


FIG. 34.—Trench filled and covered.

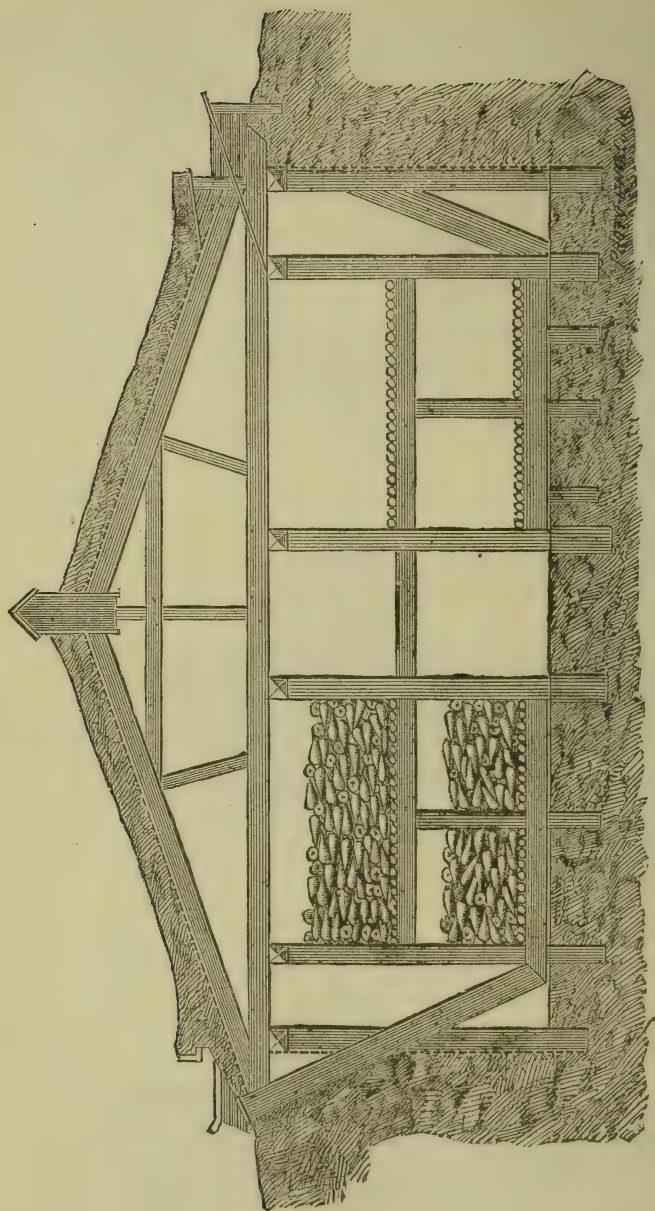


FIG. 35.—Preserving cellar (Wahlkoff). Russian plan, vertical section.

SOIL.

As has been indicated already, the character of the soil for the production of beets should be determined by actual trial. No definite rule can be given in regard to a soil from its chemical composition alone. In general it may be said that any soil which will give good crops of the cereals and other farm products will produce good sugar-beets. A sandy loam with a clay subsoil is sometimes recommended as the best for sugar-beets. In California the deposits of the coast valleys which are alluvial or lacustrine in nature have been found to produce a sugar-beet of remarkable richness. The sandy loams of the Platte Valley in Nebraska have also been found to produce a rich beet. I do not know that any scientific trials have been made in the growth of the sugar-beet on the black prairie soils so common in the prairie regions of Indiana, Illinois, and Iowa. It seems to me reasonable to suppose that these soils, after they have been cultivated for a few years in other crops, might in many localities produce a sugar-beet of high quality. The black color of the soils allows them to become most easily warmed by the early suns of spring and would tend to give an impetus to the growth of the beet which would help to carry it through in all the vicissitudes of climate which it might subsequently meet. There are many of these prairie soils which are not only dark in color but are of a loamy nature in texture and capable of being easily worked to a considerable depth. Soils which have been in cultivation for a few years are better suited for the production of the sugar-beet than virgin soils containing large amounts of organic nitrogen. All soils devoted to sugar-beet culture should have good natural drainage or else be artificially drained, so that the tap root of the beet may not reach the water-line of the soil. Very thin soils, or those which reach a hard clay subsoil at a small depth, are not suitable to beet culture, on account of affording no facilities for the penetration of the tap root. Beets grown in such soils are likely to protrude above ground and thus lose a large part of their sugar-storing room. Any soil, selected for the purpose, should have a tillable depth of from 12 to 15 inches, should be well drained, mellow in texture, not becoming hard and impacted after rains, and lending itself easily to tillage.

It is not necessary, in this place, to give many chemical analyses of soils which are found suitable to beet culture since these analyses differ very little from those of soils suitable for other crops. In general, it may be stated that the chemical analysis of a soil suitable to the growth of beets must show the ordinary percentages of the mineral substances necessary to plant growth, viz, phosphoric acid, potash, and lime. Other mineral substances which enter in minute quantities into beets are always found in sufficient quantities in all soils except those of an

extremely sandy nature. The presence of a considerable quantity of carbonate of lime is highly essential in soils growing sugar-beets, not only on account of the part it takes in supplying plant nutriment but because of its tendency to prevent the soil from becoming sour by neutralizing any acids which may be found therein, and further from the well-known effect of lime in producing flocculence of the soil which renders it difficult to impact and makes it more easily tillable. The presence of a large amount of carbonate of lime in a soil makes it porous and easily penetrated, both by the rootlets of the plant and by capillary moisture. This condition of the soil tends both to free it easily from water during times of excessive rains and to supply it with moisture in seasons of drouth. It may be well to add also that the field in which the beets are planted should be one freely exposed to the light and air, not shaded by surrounding forests nor lying in a position where its natural inclination will protect it from the rays of the sun. The importance of sunlight in the production of sugar in the beet will be mentioned in another place.

Stammer makes the following statements respecting the soil:*

"It may not be absolutely reliable to say that a soil, because of given chemical and physical properties, is perfectly adapted to the growth of beets; nevertheless, it is in general safe to accept that a soil which is of a porous nature, deep in staple, rich in humus, and more disposed to a loam or calcareous, than to a sand character, is very suitable for the cultivation of the beet, and especially if the subsoil drains off the water freely and the surface of the ground lies well towards the sun. Of course, it is included that not any of the chemical elements, such as potassium or phosphorus, which the beet is in great request of, are meagerly present in the soil.

"The lime content of the soil is most important to the beet, and soils which appear to contain but little of that compound in a free state, which is indicated by the absence of the CO_2 generation when treated with hydrochloric acid, should be well limed for the growing of beets. The action of lime upon clay soils and such as are of a sour nature, is improving physically as well as chemically by giving a milder tone to their composition and effects.

"It is further essential, or at least advantageous, that a soil for the cultivation of beets should be located at a good altitude in order that it have a free expanse to air and light. This observation has been recently established by Hanamann in his experiences, extending over several years, in growing beets in an experiment garden, the products of the experiment plots being meager and poor in quality in comparison with beets grown in the open field. A series of experiments conducted by him have led to the conclusion that the free and elevated position of the land has a decided influence upon the nature and quality of the

* Stammer, Lehrbuch der Zuckerfabrication, p. 169.

beets; and further, that the size of the beets stands in inverse proportion to their content in sugar and salts, and finally that the fine pulverized condition of the soil exerts a great effect upon the growth of the roots, *i. e.*, upon the yield of the crop.

“With the beet the choice of a suitable soil has its special difficulties, as it grows so deep in the earth, and draws much of its essential nutriment from stratas which enter less into consideration in the question of its adaptability for other crops. The nature of the so-called subsoil is, without doubt, of more decided influence upon the growth of the beet than of most other crops, and for the determination of its quality many of the essential stand-points are lacking. This is also the reason why previous experiments have given so few reliable conclusions upon the action of fertilizers. The part of the soil is fertilized from which the beet draws its nourishment during a large part of its existence, it is true, but not during the period of sugar formation, and the chemical means (such as the admixture of chloride of soda) which carry the fertilizing materials to the subsoil, are by no means sufficiently certain in their action that immediate results can be expected from experiments with them.

“On the other hand, the subsoil cultivation which brings up the lower layers of soil for the nourishment of the plant, has produced the best and most desired results in beet cultivation, and all the observations upon the influence of the use of the steam plow upon the beet harvest, and they have resulted favorably without exception, lead to the same conclusions.

“Chemical analysis, especially in its present condition, has little value for beet cultivation, in so far as it relates to the composition of soils generally known as loams, and as regards physical properties, actual experiment is the best means to determine whether a soil is adapted to beet culture or not.

“Naturally soils which do not possess the above general characteristics, for example, sandy, wet, stony, etc., are excluded, while, on the contrary, such as are known from their origin to contain an ample supply of the constituents of beet ash may be presumed in all probability to be well adapted to beet culture. Such a conclusion, however, should not be drawn too hastily from a single experiment; the effect of the necessary preparation of the soil makes itself felt but slowly, so that it is brought gradually into proper condition.”

THE CLIMATE AND SOILS OF CALIFORNIA IN THEIR RELATIONS TO BEET CULTURE.*

“The soils and climate of California have been carefully studied by Prof. E. W. Hilgard in his report published in Volume VI, Tenth Census, p. 665, *et seq.*

* Bull. 5 cit. p. 90, *et seq.*

"The following table contains data of thermal observations. It will be seen at once that the summer temperature of the interior valleys of the western or coast division is entirely too high for successful sugar-beet culture.

WESTERN OR COAST DIVISION.

[From vol. vi, Tenth Census, p. 668.]

Station.	County.	Elevation.	Years of observation.	Temperature, Fahrenheit.						
				General average.			Monthly extremes.			
				Summer.	Winter.	Year.	Summer.		Winter.	
							Maximum.	Year.	Maximum.	Year.
<i>Coast region, north.</i>										
Camp Lincoln	Del Norte	<i>Feet.</i>	2	59.5	47.2	53.9	o		o	
Fort Humboldt	Humboldt	50	16	58.2	47.0	52.9				
Camp Wright	Mendocino		6	74.7	58.8	57.8				
<i>Coast region, middle.</i>										
Napa	Napa	95	5	70.3	49.3	59.9				
San Francisco	San Francisco ..	130	11	58.0	50.1	55.2				
Oakland	Alameda	14	5	67.8	52.2	57.7	72.6	1879	49.1	1880
Martinez	Contra Costa		4	70.1	48.9	60.3	74.5	1878	41.9	1880
Jan José	Santa Clara	91	7	66.7	49.5	56.8	76.0	1879	42.2	1876
Santa Cruz	Santa Cruz	2,500	4	62.9	50.5	59.2	66.8	1881	46.2	1880
<i>Coast region, south.</i>										
Monterey	Monterey	140	12	59.7	50.2	55.5				
Salinas	do		6	60.6	50.8	55.6	65.1	1877	43.9	1882
Soledad (interior)	do	3,213	6	66.9	48.8	57.8	77.3	1876	41.8	1877
Santa Barbara	Santa Barbara ..	20	7	67.9	54.1	61.4	70.0	1874	50.4	1875
Los Angeles	Los Angeles	265	7	73.2	55.6	64.9	83.3	1877		
<i>Interior valley.</i>										
Riverside (Rio de Jurupa) ..	San Bernardino.	1,000	14	74.2	53.2	63.7				
Colton	do	965	4	80.1	50.2	65.1	86.1	1879	44.9	1882
San Diego	San Diego	64	20	69.7	54.1	62.1				

INTERIOR AND EASTERN DIVISION.

Station.	County.	Elevation.	Years of observation.	Temperature, Fahrenheit.							
				General average.			Monthly extremes.				
				Summer.	Winter.	Year.	Summer.		Winter.		
							Maximum.	Year.	Maximum.	Year.	
<i>Northern Sierra and Lava Beds.</i>											
Fort Jones	Siskiyou	2,570	5	71.1	34.1	52.3					
Fort Bidwell	Modoc	4,680	5	71.1	32.3	50.8					
<i>Great Valley (Sacramento division.)</i>											
Redding	Shasta	556	7	81.6	47.3	63.4	87.2	1879	42.5	1880	
Red Bluff	Tehama	308	10	80.8	47.5	63.7	88.9	1875	39.9	1879	
Marysville	Yuba	67	10	78.7	49.5	64.4	83.9	1871	44.4	1880	
Sacramento	Sacramento	30	10	71.8	48.2	60.8	76.9	1876	43.0	1880	
<i>Foot-hills of the Sierra.</i>											
Auburn	Placer	1,360	11	74.1	45.4	58.6	80.5	1875	39.8	1882	
<i>High Sierra.</i>											
Cisco	Placer										
Truckee	Nevada	5,934	11	60.9	32.7	45.2	73.1	1871	26.3	1880	
		5,819	11	61.1	27.7	43.3	70.3	1871	21.7	1874	1880
<i>Great Valley (San Joaquin division.)</i>											
Stockton	San Joaquin	23	10	72.5	48.2	60.8	77.7	1872	44.0	1879	
Modesto	Stanislaus	91	8	78.2	47.8	63.2	85.3	1874			
Merced	Merced	171	9	79.1	49.0	63.4	85.1	1874	40.4	1881	
Fresno	Fresno	292	5	81.1	51.3	67.6	90.0	1878	43.9	1882	
Tulare	Tulare	282	6	83.8	45.9	64.4	95.2	1874	39.1	1874	
Sumner	Kern	415	7	86.2	48.7	67.3	93.0	1875	41.9	1878	

“Following is Professor Hilgard’s description of the climate of California :

As to the change in temperature in ascending the Sierra from the valley, the following statement is made by Mr. B. B. Redding in a paper read before the California Academy of Sciences in 1878.

“It has been found that the foot-hills of the Sierra up to the height of about 2,500 feet have approximately the same temperature as places in the valley lying in the same latitude. It has also been found that with the increased elevation there is an increase of rain-fall over those places in the valley having the same latitude, as, for instance, Sacramento, with an elevation above the sea of 30 feet, has an annual mean temperature of 60.5°, and an average rain-fall of 18.8 inches, while Colfax, with an elevation of 2,421 feet, has an annual mean temperature of 60.1° and an annual rain-fall of 42.7 inches. This uniformity of temperature and increase of rain-fall appears to be the law throughout the whole extent of the foot-hills of the Sierra, with this variation as relates to temperature, viz, that as the latitude decreases the temperature of the valley is continued to a greater elevation. To illustrate, approximately, if the temperature of Redding, at the northern end of the valley, is continued to the height of 2,000 feet, then the temperature of Sacramento, in the center of the valley, would be continued up to 2,500 feet, and that of Sumner, at the extreme southern end of the valley, to 3,000 feet.”

"It is curious to note that, as appears from Mr. Redding's statement, the lowest temperature thus far observed at the two opposite ends of the valley, Redding and Sumner, are the same, viz, 27°.

"It will be noted that in the southern region the difference between the summer means or between winter means, as well as between the annual means, is quite small when Santa Barbara and San Diego, both lying immediately on the coast, are compared. At Los Angeles, 20 miles inland, all these means are notably higher; still farther inland, and with increasing elevation, the summer mean rises, while the winter mean falls at Riverside, as well as more strikingly at Colton, although at the latter point the annual mean is almost the same as at Los Angeles.

"To convey an easily intelligible idea of some of the climatic differences indicated in the table, it may be stated that while in the great valley a few inches of snow cover the ground for a short time nearly every winter as far south as Sacramento, and snow flurries are occasionally seen even at the upper end of the San Joaquin Valley, snow has fallen in the streets of San Francisco only once since the American occupation to such a depth as to allow of snowballing (which during a few hours created a state of anarchy, and only a few times has enough fallen to whiten the ground for a few minutes or hours. Hence the heliotrope, fuschia, calla lily, and similar plants endure year after year in the open air, while at a corresponding latitude in the interior they require some winter protection. Lemon and orange trees never suffer from frost on the bay, but their fruit also rarely ripens save in favored localities. In the interior these trees more frequently suffer from frost, but the high summer temperature matures the fruit some weeks earlier than even in the southern coast region. Cotton would, as a rule, be frost-killed in the great valley in November, while on the coast it might endure through several mild winters; but within reach of the summer fogs of the coast it fails to attain a greater height than eight or ten inches the first season, and sometimes can scarcely succeed in coming to bloom before October. Subtropical trees, which in the cotton stages grow rapidly and luxuriantly, such as the crape myrtle, panlownia, catalpa, mimosa (*Jubibrissin*), and others, either grow very slowly or remain mere shrubs in the coast climate, while in the interior they develop as in the Gulf States. The vine flourishes near San Francisco, but fails to mature its fruit, yet it yields abundant and choice crops near San José, where the immediate access of the coast fogs is intercepted by a range of hills. It is thus obvious that, with the varying topography, the change in the direction of a valley or mountain range, the occurrence of a gap or of a high peak in the same permitting or intercepting communication with the coast on the one hand or with the interior on the other, there exists innumerable local climates, 'thermal belts,' sheltered nooks, and exposed locations, each of which has its peculiar adaptations apart from soil, and the recognition and utilization of these adaptations require

knowledge and good judgment, and count heavily in the scale for or against success in agriculture in California.

"Rain-fall.—As regards the rain-fall, the prominent peculiarity throughout the State is the practically rainless summer. While it is true that rain has been known to fall in every month in the year, the average amount of precipitation during the three summer months is less than 1 inch in the greater portion of the States, and less than 2 inches even in the most favored part, viz, the counties just north of San Francisco Bay. Frequently not a drop of rain falls in the interior valley and the southern region from the middle of May to November, and as the agricultural system of California is based upon the expectation of this dry weather, summer rains are not even desired by the farmers at large. Northward, in the mountainous and plateau regions adjoining Oregon, the season of drought becomes shorter, as is also the case in the high Sierras, and thus there is a gradual transition toward the familiar régime of summer rains and occasional thunder-storms which prevail in Oregon and Washington west of the Cascade Range.

"Since the growing season, in the case of unirrigated lands at least, thus practically lies between November and June, and each harvest is essentially governed by the rains occurring within these limits, it is the universal and unconscious practice to count the rain-fall by 'seasons' instead of by calendar years; hence the current estimate of local rain-fall averages in California differs not immaterially from that of the usual meteorological tables, in which the paramount distinction between the *agriculturally* 'dry' and 'wet' seasons is more or less obliterated. The data hereinafter given are therefore, as a rule, 'seasonal' and not 'annual,' and are largely those of the observations conducted along its lines by the Central and Southern Pacific Railroad.

"The mean annual rain-fall of the greater (middle and southern) part of the State is less than 20 inches, the northern limit of that region lying between Sacramento and Marysville, in the great valley; while on the Sierras, the region of rain-fall, between 20 and 26 inches extends as far south as the heads of King's and Kern Rivers, furnishing the waters upon which depends the irrigation of the San Joaquin Valley; thence southward the rain gauge rapidly descends to 8 and 4 inches, and less in the Kern Valley, the Mojave Desert, and the basin of Nevada.

"A rapid decrease of rain-fall is observed in the great interior valley. From 42 inches at Redding, at the northern end of the valley, and 24 inches at Red Bluff, 24 miles to the southward, the annual mean falls to about 19 inches at Sacramento and to 16 at Stockton. Thence southward the rain-fall descends to a mean of only 10 inches at Merced, 7 at Fresno, and 4 at Bakersfield, near the southern end of the San Joaquin Valley, separated only by the Tehachapi Mountains from the western margin of the Mojave Desert, in which the rain-fall is still less.

"Along the coast proper Cape Mendocino bears the reputation of a kind of weather divide. Mariners expect a change of weather whenever

they round this cape, and on land it marks the region where the character of vegetation begins to change rapidly from that of southern or middle California toward that of Oregon. At and immediately north of the cape the rain-fall reaches an annual mean of 40 inches. A short distance southward, at Point Arenas, the annual fall is 26 inches, and from 23 to 21 inches in the region of San Francisco; it falls to 16 inches at Monterey and Santa Barbara, 12 at Los Angeles, and 9 at San Diego.

"Northward of Cape Mendocino the rain-fall increases rapidly, rising to over 70 inches in the northwestern corner of the State. Inland from the coast the increase is less rapid, but the rain-fall rises at points in the Shasta region to as much as 108 inches in some years. Southward the region of rain-fall exceeding 20 inches extends in the coast range slightly farther south than in the great valley, so as to include all but the most southerly portions of the counties of Sonoma, Napa, and Marin. Southward of San Francisco again a region of more abundant rain-fall includes the western Santa Clara Valley, Santa Cruz Mountains, Monterey Bay, and the lower Salinas Valley, where from 13 to 16 inches fall annually.

"Ascending the Sierra from the great valley there is a rapid increase of rain-fall, which, from data furnished by the records of the railroad, may be estimated at 1 inch for every 100 to 150 feet of ascent.

"The following tables show more in detail the rain-fall averages for representative points, the data being derived mainly from the observation made under the auspices of the Central and Southern Pacific Railroad and given for 'seasons' reaching from July to June inclusive.

WESTERN OR COAST DIVISION.

Station.	County.	Elevation.	Years of observation.	Average.	Maximum.	Year.	Minimum.	Year.
		Feet.		In.	In.		In.	
<i>Coast Range, north.</i>								
Camp Lincoln	Del Norte	95	5	26.6	34.7	1877-'78	17.1	1881-'82
Fort Humboldt	Humboldt	130	10	20.7	32.1	1877-'78	8.8	1876-'77
Camp Wright	Mendocino	14	5	20.6	29.3	1877-'78	9.6	1881-'82
<i>Coast Range, middle.</i>								
Napa	Napa	4	4	16.1	19.7	1880-'81	12.9	1881-'82
San Francisco	San Francisco	91	8	11.4	19.3	1877-'78	5.0	1876-'77
Oakland	Alameda	2,500	5	26.4	39.2	1877-'78	22.0	1878-'79
Martinez	Contra Costa							
Sar. José	Santa Clara							
Santa Cruz	Santa Cruz							
<i>Coast Range, south.</i>								
Monterey	Monterey	140	12	15.7	23.7	1877-'78	3.9	1876-'77
Salinas	do		9	12.8	23.7	1877-'78	3.9	1876-'77
Soledad (interior)	do	3,213	8	7.9	15.3	1875-'76	2.7	1876-'77
Santa Barbara	Santa Barbara	20	11	16.2	31.5	1877-'78	4.5	1876-'77
Los Angeles	Los Angeles	265	7	12.0	21.9	1875-'76	4.6	1876-'77
<i>Interior Valley.</i>								
Riverside (R. de Jurupa)	San Bernardino	1,000	13	13.6	23.7	1877-'78	5.9	1876-'77
Colton	do	965	6	8.2	14.5	1877-'78	5.9	1876-'77
San Diego	San Diego	64	20	9.3				

INTERIOR AND EASTERN DIVISION.

Station.	County.	Elevation.	Years of ob- servation.	Average.	Maximum.	Year.	Minimum.	Year.
<i>Northern Sierra and Lava Beds.</i>		<i>Feet.</i>		<i>In.</i>	<i>In.</i>		<i>In.</i>	
Fort Jones	Siskiyou.	2,570	5	21.7				
Fort Bidwell.....	Modoc.....	4,680	5	20.2				
<i>Great Valley (Sacramento Division).</i>								
Redding	Shasta.....	556	7	42.1	60.0	1877-'78	25.4	1881-'82
Red Bluff	Tehama.....	308	10	24.0	52.7	1877-'78	13.6	1874-'75
Marysville	Yuba.....	67	11	17.8	26.9	1873-'74	12.2	1876-'77
Sacramento	Sacramento..	30	32	18.7	25.5	1875-'76	9.2	1876-'77
<i>Foot-hills of the Sierra</i>								
Auburn.....	Placer.....	1,360	11	34.0	44.3	1875-'76	18.9	1876-'77
<i>High Sierra.</i>								
Cisco	Placer.....	5,934	11	60.8	82.7	1880-'81	34.1	1876-'77
Truckee	Nevada.....	5,819	11	34.1	44.0	1871-'72	18.0	1876-'77
<i>Great Valley (San Joaquin Division).</i>								
Stockton	San Joaquin..	23	32	15.8	20.6	1871-'72	7.2	1876-'77
Modesto	Stanislaus ..	91	11	9.6	13.4	1875-'76	4.3	1876-'77
Merced	Merced.....	171	10	9.7	12.7	1875-'76	3.2	1876-'77
Fresno	Fresno.....	292	5	7.0	8.9	1877-'78	4.9	1878-'79
Tulare	Tulare.....	282	8	6.2	10.0	1880-'81	3.1	1878-'79
Sumner	Kern.....	415	7	4.2	8.0	1877-'78	1.3	1878-'79

“Were the rainfalls of 20 inches and less distributed over the whole or even the greater part of an ordinary season of the temperate zone, it would be altogether inadequate for the growing of cereal or other usual crops of that zone; but since in California nearly the whole of it usually falls within six months (November and April inclusive), and by far the greater part within the three winter months, during which a ‘growing temperature’ for all the hardier crops commonly prevails, it becomes perfectly feasible to mature grain and other field crops before the setting in of the rainless summer, provided only that the aggregate of moisture has been adequate and its distribution reasonably favorable. The grain sown into the dust of a summer-fallowed field begins to sprout with the first rain, and thenceforward grows more or less slowly, but continuously, through the winter. It is ready to head at the first setting in of warm weather, from the end of March to May, according to latitude, and becomes ready for the reaper from the end of May to the end of June. Once harvested, the grain may be left in the field for several months, thrashed or unthrashed, without fear of rain or thunder storms. As a matter of course, the grain-grower may also, at his option, sow his grain at any time after the beginning of the rains, and good crops are sometimes obtained from sowings made late in February. Usually, however, the late-sown grain is cut for hay when in the milk, in April and May, for, since meadows can form no part of the agricultural system, except where irrigation is feasible, the

hay grasses commonly grown in the Eastern States are available only to a limited extent, and wheat, barley, and oats take their place. Again, there is no strict distinction or limit between fall and spring grain, since the sowing season extends from October to February. Thus the winter months are a very busy season for the farmer in California, as he has to watch his opportunity for putting in his crops between rains. The time between lying-by and harvest is nearly filled up by gardening and haying operations. The latter are occasionally interrupted by one or two light showers, rarely enough to injure the quality of the hay. Protracted rainy spells or thunder-storms, calling for hasty gathering of the cut grain into shocks, are unknown in harvest time, as are also sprouted or spoiled grain, except when the sacked grain is left out in the fields so late as to catch the first autumn rains. It will thus be seen that midsummer finds the California grain-grower comparatively at leisure.

“But while the culture of hardy plants of rapid development was the first and most obvious expedient resorted to by the American settlers, in order to utilize the fertile soils of the region of rainless summers, that of selecting culture plants adapted to arid climates was the one naturally suggesting itself to the missionary padres, who brought with them from the Mediterranean region of Europe the vine, the fig, the olive, the citrus fruits, as well as from adjacent portions of Mexico the culture of cotton, to which, however, but little attention was given by them, the growing of wool being better adapted to the temper of their native laborers. And as they relied largely on irrigation for the success of their annual crops, it was only in very extreme cases that a deficient rain-fall so affected their interests as to give the fact a place in their records.

“*Variation and periodicity of rain-fall.*—While the means of rain-fall given above will not vary widely when any large numbers of years are taken together, the variations from one year to another are often sufficiently great to tempt many to invest heavily in putting in crops on the chances of a favorable season, which would bring a fortune at one venture, but sometimes results in a total loss and consequent ruin to investor. Such cases of agricultural gambling were at one time not uncommon in the San Joaquin Valley especially, the turning point of profit or loss being a single light shower at the critical time or the occurrence of a norther for a day or two. More ingenuity has been spent in trying to forecast the weather for the season in time to determine the chances of success, but it will generally be found that the oldest citizen, if he is candid, will be far more reserved in his opinions than later comers.

“However steady and reliable the summer climate may be, that of a California winter is most difficult to forecast from day to day and from week to week, and while there are certain rules that are ordinarily counted upon, the cases where ‘all signs fail’ are very frequent, and surprises are abundant. A discussion of the observations made from

1849 to 1877, by Dr. G. F. Becker, late of the University of California, and now of the United States Geological Survey, seems to indicate as probable a cycle of thirteens years between extreme minima of drought years, and some data I have since obtained from the records of the missions seem to confirm still further this conclusion. The first minimum within the time of the American occupation of California occurred in the season of 1850-'51, when the rain-fall at San Francisco was 10.1 inches, and the third was the season of 1876-'77, with 10 inches. The next succeeding season of minimum would be that of 1889-'90.

Number.	Soil title.	Locality.	Depth.	Vegetation.	Insoluble residue.
COAST RANGE REGION.					
<i>South of San Pablo Bay.</i>					
168	Valley soil.....	Santa Paula, Ventura County.....	12	.....	85.664
182	Reddish mountain soil.....	do.....	12	Grass, herbs.....	74.930
170	Bench-land subsoil.....	Hollister's ranch, Santa Barbara County.	12-18	Oaks.....	83.065
600	Upland soil.....	Poverty Hill, San Benito County...	12	Cultivated 12 years...	85.596
606	Upland loam soil.....	Soquel ranch, Santa Cruz County...	12	Cultivated.....	80.426
702	Chaparral soil.....	Two miles northeast of Saratoga, Santa Clara County.	12	.....	57.449
37	Valley soil.....	Pescadero, San Mateo County.....	.....	Redwood, pine, oak, alder, buckeye, and madrone.	78.084
680	Sandstone soil.....	San Francisco, San Francisco County.	8	Scrubby live-oak.....	78.135
682	Sandstone subsoil.....	do.....	8-18	.....	70.224
643	Black waxy adobe soil.....	Cobton ranch, Contra Costa County.	12	Sunflower.....	50.960
692	Dark soil, rolling uplands.	Livermore Valley, Alameda County.	6	Scattering white oak and poison-oak.	80.262
693	Dark subsoil, rolling uplands.	do.....	6-18	do.....	80.658
694	Red gravelly soil, rolling uplands.	do.....	8	do.....	81.941
649	Sediment soil.....	Arroyo del Valley, Livermore Valley, Alameda County.	....	Shrubs, herbs, and some sycamore.	71.156
1	Black adobe soil.....	University grounds, Alameda County.	12-22	Live-oaks, large.....	....
2	Subsoil No. 1.....	do.....	22-30	do.....	....
4	Adobe ridge subsoil.....	do.....	10-20	Scattered live-oak, small.	....
<i>North of San Pablo Bay.</i>					
185	Valley soil.....	G. F. Hooper's vineyard, Sonoma County.	12	Oaks and gape-vines.	76.089
188	Red mountain soil.....	do.....	12	Oaks, manzanita chaparral.	34.292
207	Eel River bottom soil.	Three miles east of Ferndale, Humboldt County.	12	.....	65.346
205	Subsoil of No. 207.....	do.....	12-25	.....	69.373
676	Red volcanic soil.....	Flat on Clear Lake, Lake County...	12	Not known.....	49.604
672	Gray valley soil.....	Two miles south of St. Helena, Napa County.	12	Large white oak.....	77.017

subsoils. [Vol. vi. Tenth Census, p. 738.]

Silica soluble in Na ₂ CO ₃ .	Total insoluble residue and silica.	Potash.	Soda.	Lime.	Magnesia.	Brown oxide of manganese.	Ferric oxide.	Alumina.	Phosphoric acid.	Sulphuric acid.	Carbonic acid.	Water and organic matter.	Total.	Hygroscopic moisture.	Temperature of absorption = C.	Analyst.
1.84787.5110.6340.0700.7590.5930.025	7.91282.8420.6210.1640.9520.9550.036	4.67887.7130.5960.0580.5610.6660.055					3.350	3.0990.2000.003				3.132	99.372	5.49	15.0	Jappa.
							5.070	5.9360.1270.039				2.669	99.414	6.59	15.0	Do.
							3.116	2.9950.2230.094				3.854	99.871	5.98	15.0	Do.
2.56788.1630.3330.1090.6760.5260.048	3.02881.4540.3430.1260.5020.3900.014						2.856	4.2140.0270.015				3.476	100.443	5.22	12.5	Do.
							3.928	5.7110.0530.009				4.955	99.485	5.60	15.0	Do.
5.11462.5630.8590.2601.9872.4280.098							10.019	9.5160.1390.063				11.921	99.853	12.09	15.0	Do.
3.23781.3210.5410.2310.9250.8200.039							4.934	4.8210.0840.027				6.757	100.500	7.38	15.0	Do.
3.4581.5930.6750.0800.8460.7880.053							5.682	5.1620.0310.053				5.404	100.359	6.02	15.0	Morse.
5.53275.7560.5900.1720.3991.2210.059	9.02059.9800.1920.7412.4710.8900.065						7.268	9.7370.0110.022				4.900	100.135	9.41	15.0	Do.
5.02185.2850.2990.1080.8130.6470.065							11.090	15.6890.0570.045	Trace			8.304	99.524	13.51	15.0	Do.
							3.584	4.9330.0600.010				4.047	99.857	5.67	15.0	Jappa.
5.15785.8150.3570.1210.6930.6660.025							3.647	5.3290.0620.008				3.435	100.158	6.12	15.0	Do.
3.75685.6970.3230.0810.7200.5630.030							3.620	5.5400.0610.008				3.550	100.193	4.53	15.0	Do.
4.93876.0941.1430.1232.0493.0460.044							5.648	7.1530.1170.101	1.004			3.679	100.201	5.67	15.0	Do.
.....77.8440.4520.0741.0501.2110.078							4.675	7.7880.2310.077				5.718	99.198	....	15.0	Sutton.
.....69.5630.3480.1090.9981.9135.093							7.208	13.9700.1160.028				6.600	100.946	.....	.....	Do.
.....86.0020.1890.1540.4340.4520.038							4.013	5.5320.0570.021				4.051	100.993	.....	.....	Do.
6.83982.9280.4350.1230.7440.5780.025							5.793	5.0920.1870.171				3.715	99.791	4.98	15.0	Jappa.
14.11048.5020.3190.0580.6700.7120.146							25.955	12.1600.1660.274				11.640	100.602	13.71	15.0	Do.
6.89672.2421.1270.2820.1053.3290.117							6.986	10.2360.1670.020				5.629	100.240	7.87	15.0	Do.
3.58872.9611.1340.1200.1013.2390.054							7.307	9.7580.1410.026				4.665	99.506	6.21	15.0	Do.
5.93455.5380.4520.1700.6580.6100.051							10.477	22.5850.0310.033				9.654	100.259	11.11	15.0	Morse.
3.34080.3570.7460.4710.6001.3310.041							5.656	5.6710.1010.050				5.252	100.282	4.50	15.0	Do.

Soils of the southern region.

Constituents.	Los Angeles County.			San Diego County.	
	Soil of San Gabriel Valley.	Pomona Colony.		Soil of mesa land.	Bottom soil Colorado River.
		Low mesa soil.	Subsoil.		
		No. 130.	No. 382.			No. 381.	No. 48.	No. 506.
Insoluble matter.....	{ 81.12	{ 72.519	{ 75.304	86.21	{ 58.574
Soluble silica.....		5.121	3.872		5.327
Potash.....	0.21	0.839	0.962	0.48	1.177
Soda.....	0.17	0.296	0.301	0.14	0.162
Lime.....	0.68	2.354	2.052	0.36	8.671
Magnesia.....	1.77	2.225	2.154	0.54	2.966
Brown oxide of manganese.....	0.10	0.039	0.043	0.10	0.025
Peroxide of iron.....	6.30	8.097	7.342	3.69	4.139
Alumina.....	6.79	5.974	5.835	5.12	8.379
Phosphoric acid.....	0.16	0.018	0.049	0.23	0.133
Sulphuric acid.....	0.07	0.022	0.020	0.03	0.145
Carbonic acid.....					7.818
Water and organic matter.....	3.07	2.550	2.546	2.60	3.344
Total.....	100.50	100.054	100.480	99.50	100.860
Humus.....		0.324		0.555	0.752
Available inorganic.....		0.263		1.439	1.151
Available phosphoric acid.....					0.133
Hygroscopic moisture.....	2.30	3.460	2.370	2.340	9.204
Absorbed at.....	15° C.	15° C.	15° C.	15° C.	15° C.

“There are many parts of the ‘valleys of the Coast Range’ where the soil is suitable for beet culture. The following table gives the areas of this soil in regions where the climate will permit beet culture. The areas for each county are as follows:

“The area of soil suitable for beet cultivation, by counties.

	Square miles
Los Angeles.....	1,480
San Bernardino.....	465
San Mateo.....	50
Contra Costa.....	70
Alameda.....	225
Santa Clara.....	405
Monterey.....	700
San Benito.....	115
San Luis Obispo.....	1,090
Santa Barbara.....	300
Ventura.....	170
Sonoma.....	350
Napa.....	145
Other valleys.....	40
Lake.....	100
Mendocino.....	125
Sum.....	5,830

“This gives a total area in acres of 3,731,200. Granting that two thirds of this area are unfit for beet culture for lack of moisture and local causes, there remains over a million and a quarter acres on which

beets could be grown. Of this area not less than half a million acres could be cultivated annually. From the data of yield of beets per acre and sugar per ton of beets, already given, the average may be put at 15 tons and 9 per cent., respectively, or 2,700 pounds of sugar per acre. For 500,000 acres this would give 1,250,000,000 pounds.

THE SUGAR-BEET IN OREGON AND WASHINGTON TERRITORY.

"I was anxious to extend my investigations of the possibilities of beet culture into Oregon and Washington Territory, but the limited time at my command prevented this design from being carried into execution.

"Having learned that Mr. E. Meeker, of Puyallup, Wash., had been engaged in the cultivation of beets, I addressed him a letter making inquiries concerning the matter.

"In answer I received the following communication. I regret to say the samples of beets which Mr. Meeker hoped to be able to forward for analysis have not been received.

"Mr. Meeker says:

"I am in receipt of your favor of 21st ultimo from San Francisco, and herewith inclose an article to answer your question with reference to growing sugar-beets in Oregon and Washington.

"I will send you samples of beets grown by myself, and from others if I can obtain them. T. M. Alvord, White River, Wash., takes great interest in this question; also J. W. Sprague, Tacoma, Wash., and James McNaught, Seattle, Wash. I would also suggest to send to the secretaries of the chambers of commerce of both Seattle and Tacoma.

"I send you paper containing an article of mine giving the cost in detail of our present year's crop.

"My article refers only to Puget Sound country, or what is here known as western Washington. I am not fully advised as to the valley lands of Oregon, but I think their heavy clay wheat-lands unsuitable. I also think the prairie, or in fact any lands of eastern Oregon or Washington, are unsuited from the excess of alkali contained in the soil, also from scarcity of fuel.

"The climate of western Washington is mild and equable, neither very cold in winter nor hot in summer, and seems to be exactly suited to growing the sugar-beets to perfection.

"There is always an abundant rain-fall in summer, so that we never have a failure of crops; the autumns are free from heavy frosts or freezing weather (at this writing, December 1, there has as yet been no freezing weather), but usually there is considerable rain.

"We do not irrigate; in fact the soil is loose and favorable, so that our crops grow well the whole season, and remain green even during a 'dry spell,' which, however, seldom occurs of sufficient duration to endanger crops. The growing season is very long, and all hardy vegetables are produced in great abundance and perfection.

"Soil suitable for producing the sugar-beet is in the alluvial bottoms adjacent to various rivers flowing from the Cascade range of mountains towards salt water.

"These rivers are not large nor the valleys wide, but are numerous; in the Puget Sound Basin there are eleven or more situated north of the Columbia River and south of our northern boundary. I should say the area of land in each of these valleys suitable for beet-culture would average sixty sections of land, or say about 40,000

acres each. This is nearly all timber land and requires clearing, is a deep alluvial sandy loam, very rich, and produces an abundant and certain crop.

"Fuel is abundant, and is widely distributed. The coal is under the table-land or foot-hills of the Cascade range of mountains, and is reached by short lines of rail-roads. The aggregate monthly output of the mines opened is, I think, about 30,000 tons. It can be increased indefinitely, as the coal area is large, the veins numerous and heavy (thick).

"So far, our sugar-beets have been not only rich but also singularly pure. This is probably to be accounted for from our heavy rain-fall and agreeable climate. The actual cost of raising per ton for a period of five years has been less than \$2.50 per ton, and the present year \$2.25 per ton. We have grown them for cattle, and could utilize the pulp to great advantage in stall-feeding beef.

"Our winters will admit of working sugar-beets nearly the whole time, the weather seldom being cold enough to interfere with harvesting the beets. Locations can be had where transportation is cheap, where fuel is cheap, where land is cheap, and where the market for sugar is good. It would seem to be difficult to find better conditions for the successful inauguration of this business than here exist, and we firmly rest in the conviction that sooner or later the capital will be found to develop these favorable conditions, and that the day is not far distant when we shall see numerous beet-sugar factories producing not only enough for the immediate home consumption, but also for the great interior country of this continent.

"Following are the results of culture mentioned in the foregoing letter :

"I raised the present year 65 tons of beautiful sugar beets from 2 acres of land. There was no guess work; it was 65 tons of 2,240 pounds from the two measured acres. These cost me \$2.25 per ton, and I will give this in detail that your farmers may ponder this question and see that I do not understate the cost:

Plowing and subsoiling two acres.....	\$20.00
Harrowing and clod mashing.....	6.00
Rolling.....	4.00
Planting.....	2.00
Seed.....	4.00
Cultivating (machine work).....	16.25
Hand weeding.....	20.00
Harvesting.....	21.50
Housing, 50 cents per ton.....	32.50
Rent of land.....	20.00
Total.....	146.25

"My neighbor, Mr. T. M. Alvord, of White River, has for five years raised an average of 100 tons a year at an average cost of less than \$2.50 per ton and an average yield of 20 tons per acre. We know that the beets can be raised; that the crop is certain; that the quality is good, pure, rich—in a word, everything desired to make this industry profitable, and now shall we throw this opportunity away, encourage the importation of foreign sugar made by cheap, servile labor, or shall we encourage home production and all the benefits that follow?"

"The following account of the topography, climate, and soils of the Chehalis Valley is taken from an article printed in Gray's Harbor News, Chehalis County, Wash., April 19, 1884:

"TOPOGRAPHICAL FEATURES.

"Western Washington is a name given to that portion of country lying between the Pacific Ocean and the Cascade Mountains, the Columbia River and British America. On its eastern border the Cascade Range, an unbroken chain containing the

highest peaks in the United States, stands like a lofty wall, shutting out and hiding the beautiful and fertile country west from the rest of the world. West of this lofty range lies a strip of country about one-half the size of the State of New York, about 110 miles wide and from 200 to 250 miles long. In the southwestern portion of this country, lying near the Pacific and jutting close upon the Columbia River, is a cluster of high hills, and in the northwestern portion, on the peninsula formed by Puget Sound and the Pacific, is the Olympic Mountains, another cluster rising to the height of 8,000 feet. In the north is Puget Sound, perhaps the most beautiful inland sea in the world, with its lofty wooded shores, its innumerable windings and islands, and its deep, clear water. The shores of this sound are high and rocky. But few streams flow into it, and these chiefly on its eastern side. In the southeastern part the Cowlitz River flows along the base of the Cascades in a southerly direction and empties into the Columbia. But in the central part, rising among the hills in the southwestern corner and flowing first east then north, so that the Kalama Branch of the Northern Pacific passes along it, and then west, is a magnificent stream, the Chehalis River, emptying into Gray's Harbor and so into the Pacific Ocean. This is the largest river in Western Washington. It is the only river of any size not subject to summer floods caused by the melting of mountain snows. This river, with its tributaries and including Gray's Harbor, drains a basin of some 3,500 square miles; (the map shows sixty townships, and a greater amount may fairly be reckoned as part of this river valley). As will be seen, Chehalis County is the very heart of western Washington, and it is the heart in a very true sense, in that all that is desirable in western Washington is centered here in its best condition, and here are the means, the forces that are to give life and growth to all the rest.

"CLIMATE.

"From October 13 to November 13, thirteen rainy days, thirteen fair days, and five clear days; from November 13 to December 13, twelve rainy days, thirteen fair, and four rain and shine; from December 13 to January 13, one day snow, six rain, three rain and shine, fourteen fair, and eight clear days; from January 13 to February 13, three days snow, four rain, two rain and shine, ten fair, and twelve clear days; from February 13 to March 13, five days snow, three rain, one rain and shine, sixteen fair, and four clear days; total for the winter, nine days of snow, thirty-eight rain, ten rain and shine, sixty-six fair, and thirty clear days. Days are called clear when not a cloud appears. During this time the range of the thermometer was: First month—lowest 40°, highest 65°, and the average 53½°; second month—lowest 34°, highest 55°, average 41½°; third month—lowest 28°, highest 50°, average 37½°; fourth month—lowest 9°, highest 45°, average 23½°; fifth month—lowest 27°, highest 42°, average 36¾°. The record of 9° above was the lowest point reached during the last seven years. There was one fall of snow that reached a depth of 6 inches. The record of lowest thermometer for the last seven years is: For 1876-'77, 22°; for 1877-'78, 20°; for 1878-'79, 10°; for 1879-'80, 10°; for 1880-'81, 28°; 1881-'82, 20°; 1883, 9°.

"THE SOIL.

"The soil of the uplands, or hills, is loamy, in places gravelly. It is quick, warm but not strong land as a rule. In some localities where upland clearings have been made reports are given of large crops. It is better adapted to fruit and general gardening. Some of the hills are doubtless good land. It all grades off into bottom-land. It is difficult to clear for the immense growth of timber. But in this climate most of these hills will be profitably farmed. Indeed, almost anywhere clover and timothy grass will flourish luxuriantly. But it is the *bottom-land* that is chiefly valuable at present for farming. Thus far the most part is easily cleared, and is as good land as can be found anywhere. It will produce good crops of almost anything, and its fertility is inexhaustible. One piece that has been cultivated almost continuously

for twenty years, with no manuring, is to-day as rich as when first plowed. This land is all made land. It is a mixture of alluvial wash and vegetable and animal matter. It is more like garden than field land. A few acres will yield more than a quarter section of much of the land East.

"The bottom-lands in general are subject to winter overflow, though some of them rarely, if ever, are covered. They are apt to be broken by channels which this overflow has made and by sloughs and streams which flow through.

"There is much of this bottom-land. Along each of the principal streams there are wide stretches of it, and along in each stream in this whole Chehalis country there is more or less. But as there are few quarter-sections across which some stream does not flow, so there are few which do not possess some of this bottom-land.

"These bottom-lands that lie down toward the sea are subject to periodical overflow by the tide, and there is a large amount of this about Gray's Harbor and the streams that empty into it. These are in places largely open and covered with a rank growth of wild grass. They are used now principally for pasture. But a dike from 1 to 3 feet high would keep out this tide, and when so diked they are equal to the best of bottom-land. No better land can be found.

"In view of the preceding description I am inclined to believe that in Washington and Oregon soil and climate are very favorable to the growth of a sugar beet of high saccharine strength.

"The mildness of the winter is, though to a less degree than in California, favorable to the season of manufacture. With a wise and careful encouragement of the industry I have no hesitation in saying that the prospects for the development of an indigenous sugar industry in the extreme northwestern part of our country are decidedly bright. It is a field worthy the attention both of experimenters and capitalists."

SOIL AND CLIMATE IN BOHEMIA.

In respect of the soil in Bohemia best suited to the sugar-beet, John B. Howes, commercial agent, makes the following observations:*

"The best soil for quality, as well as quantity of production, according to the experiments of Orth, are those that consist of mild, moist loam about 50 centimeters deep, then loam or marl 1 to 2 meters, and under this sand. Such soils, which are easy to cultivate, have a high degree of absorption, can combine nourishments, and give the plant physically a good start. Such soils are called 'natural sugar-beet soils.'

"It is possible to raise beets on soils that do not have all these qualities, but the crop will be the better the nearer this standard is approached.

"The conditions required for a good sugar-beet soil are—

"(1) Depth, because the roots mostly take their nourishment from a depth of 30 centimeters, and the soil must therefore be loosened and contain nourishment up to this depth.

"(2) Porousness of the subsoil, because it is impossible to cultivate a damp, cold soil at the right time. Such a soil will become cracked if very dry, and the young plants suffer, while the beets will contain little sugar. In such a case drainage must be employed. Clay soils can be

*Report to State Department, page 242.

improved by manuring, by the use of lime, and drainage; light soils by manuring and loamy marl.

"Leplay found that the heaviest beets will be raised in descendant succession, from clay, lime, loam, and sand soils; beets with the greatest percentage of sugar in lime, clay, sand, and loam soils; the most leaves in sand, clay, lime, and loam soils. According to experiments of Marek, the more moisture in the soil the greater will be the development of leaves. This influence is stronger in sand soil than in one of clay. The normal development of the root depends upon organic matter in the soil. The more moisture there is in the soil the looser the texture, the poorer the quality, and the less sugar will be in the beet.

"The following soils are adapted for the culture of the beet, if they have a good subsoil: Loamy soils, mild, clayey, or sandy, and clay marl. Of clay soils, the mild and loamy ones; if the amount of clay is excessive, the soil must be made suitable by manuring. Strong clay soils are useless for beets, but clay marl soils are good. Sandy soils are least adapted to the cultivation of the sugar-beet, with the exception of loamy sand soil not deficient in humidity and the subsoil possessing enough water-holding power. Lime soils are, with the exception of loamy lime soil, not good for beets. From moist soils are raised good quantities, but poor qualities.

"The best locations for sugar-beet planting are on level or only slightly sloping lands, because work is done best on such lands, and it is impossible for the beets to be swept away by heavy rains."

In regard to climate, Agent Howes has collected the following data (*op. cit.* p. 242):

"In Europe the sugar-beet is successfully planted between the forty-seventh and fifty-fourth degrees of northern latitude; in Germany, between the fifty-first and fifty-fourth; in France, between the forty-seventh and fiftieth; in Austria-Hungary, between the forty-eighth and fiftieth; and in Russia, between the forty-eighth and fifty-third degrees.

"Like all plants, the sugar-beet requires certain conditions of climate to arrive at perfection.

"According to the experiments of Briem, director of the experimental station in Grussbach, Moravia, concerning the distribution of warmth and rain-fall during the period of vegetation of the sugar-beet in the first period, *i. e.*, in the first two months, the time of germinating, the daily temperature was 10.70° C.; in the second period (the time of the development of the vegetative organs), 18.8° C.; and in the third period (in which the storage of the reserve substances takes place), 16.5° C.; and during the whole vegetation, 15.3° C.

"The total warmth in the first period was 650° C.; in the second, $1,150^{\circ}$ C.; and in the third, $1,000^{\circ}$ C.

"The rain-fall was in the first period 97 millimeters; in the second,

114 millimeters; and in the third, 100 millimeters—together 311 millimeters.

"The sugar-beet needs much warmth and light, sunny days, and a certain amount of moisture.

"The best climate for sugar-beets is the so-called 'wine climate,' with a temperature from 9° to 10° C. in April and May, 17° to 18° C. in June and July, and 15° and 12° in August and September, respectively.

"The sea-coast is not warm enough and has not enough sunny days in June and July to be successful for sugar-beet raising.

"For the first period of vegetation it is necessary that a certain amount of winter moisture be in the ground, as the seeds need moisture to germinate. In the second period warmth and moisture is required for the production of roots and leaves. In the third period, in which the saccharification goes on, dry warmth. If the days be sunny, the beets will become rich in sugar; but if this period be wet, the crop will be great in quantity, but poor in quality. If, after a dry summer, a warm and rainy fall follows, new leaves spring up at the cost of the sugar."

The following observations on soil, culture, and fertilization will be found interesting in connection with the foregoing discussion.*

"The cultural conditions to be regarded as of greatest importance in securing crops of maximum quantity and quality, when a section has been determined upon by a consideration of all other conditions, are choice of soil, etc., its physical character and chemical composition, and the methods by which these may be modified or improved; the first by the mechanical methods of culture, and the second by the proper and judicious applications of fertilizers. After this will naturally follow the modes of planting and the care to be applied during the season of growth.

"With reference to the choice of soil suited to the culture of the beet-root, opinions seem to differ somewhat, though the principles which appear to govern them tend to the same end. The illustrious Chaptal,† as a result of his study of the plant and its requirements, arrived at the following conclusions:

"Soils which are dry, calcareous, light, etc., are not well suited to the beet.

"Strong clay soils have little aptitude for the culture of this root.

"In order that the root may prosper, it needs, in general, a mellow, fertile soil, the arable stratum of which should be 12 to 15 inches thick.

"The root succeeds more or less well in all arable soils, but the products vary wonderfully according to the nature of the soils.

"Basset‡ considers that "a fresh soil, rather sandy or silico-calcareous than too calcareous or argillaceous, rich in humus, and deep," should be

* McMurtrie *op. cit.*, pp. 95-117)

† Quoted by Basset in *Guide Pratique du Fabricant de Sucre*.

‡ Ibid.

chosen. Briem,* in his late work on beet-root culture and sugar manufacture, says, of the physical character of the soil to be chosen, "it should not be too light nor too moist; it should be bare; its subsoil permeable; it should be warm, free from stones, calcareous, and should contain humus." Deherain,† from the results of his experiments and investigations at Grignon, publishes as one of the conclusions arrived at that the nature of the soil does not seem to exercise any sensible action upon the development of the beet, for the same results were obtained in soils consisting of pure silica, of calcareous matter, or of a mixture of calcareous matter and clay.

Vivien‡ found in traveling through the provinces of the Rhine, Hanover, Brandenburg, and Saxony in Germany, that, though in each section there is a wide difference in the nature of the soil, there is a particularly marked homogeneity in the character of the beets.

"Vilmorin considers that any good soil that will grow wheat and corn and has an arable stratum of 12 to 15 inches, will be well suited to this culture; that where chalk exists in large proportion the yield will be small, but the juice pure. All soils should be thoroughly drained, so that the tap root may not find stagnant water in the subsoil.

"Notwithstanding the differing notions expressed above, it will appear that the physical characters of the soil which tend to render it best suited to the cultivation of the beet are porosity of surface and subsoil, to admit of drainage of superfluous water and of free circulation of the air, and power of absorbing and holding in a condition convenient for ready assimilation the elements of plant-food existing within it or coming from external sources. Unless the supply of these elements be continuous and regular, a purely sandy soil would be undesirable. If no means were provided for the removal of surplus water which might be found in a purely clay soil, or to so improve its condition as to admit of free circulation of air as well as water, it is too heavy, and becomes absolutely useless. The same is true of purely calcareous soils, since the same unfavorable conditions would prevail, though perhaps to not quite the same extent. These soils would also be unsuited to the plant itself, because they would not admit of the free progress of the tap root nor of the lateral fibrous roots in their search for nutrition or in following the natural course of development, and, as will appear later on, these conditions have a powerful influence upon the ultimate yield of sugar from the surface cultivated. But if the sandy soil described be mixed with either or both of the others mentioned, and with humus, in suitable proportions, the conditions most favorable to the maintenance of a regular and plentiful supply of food, the healthy condition of the root, and its consequent normal development, will be assured.

* See Critique in *Journal des Fabricants de Sucre*, 1879.

† *Annales Agronomiques*.

‡ *Journal des Fabricants de Sucre*, 1878, 27 March.

"The chemical character of the soil is of quite as great importance as its physical condition. For the proper development of the beet for the production of sugar it should contain in a suitable and assimilable form all the elements usually necessary to the normal existence and development of plants, and attention must therefore be had to the conditions in which these substances exist in the soil. Phosphoric acid, potash, nitrogen compounds, and lime are especially necessary to the life of the plant, but if these exist in insoluble combinations on the one hand, or in forms suitable for assimilation but in excessive quantities on the other, they will either be useless in the economy of nutrition in the first instance, or will stimulate the plant to abnormal growth unsuited to the ready extraction of sugar in the second. It is this branch of the subject that has occupied the attention and enlisted the energies of scientists and landed proprietors, and the influence of the different combinations of the various leading elements of plant-food, and more especially, during later years, of nitrogen in the soil, has constituted the subject of frequent and continued investigation.

"Basset* says :

"Soils charged with mineral salts are injurious to the culture of the beet for extraction of sugar, and are only suited to the cultivation of beets for distillation. In fact, we know that the beet easily absorbs saline matters and that the alkaline salts constitute one of the greatest obstacles to sugar extraction.

"New ground, or that lately cleared of forest, should not be applied to the culture of the beet, and it is considered by good authorities to be detrimental to the quality of the crop to make use of lands for this purpose that have not been under continued cultivation at least ten or fifteen years. This insures an almost complete removal of the nitrates and the organic matters containing nitrogen, which are always present in large quantities in new soils, and which it is well known exert an injurious influence upon the quality of the root.

"Basset, in his work,† gives elaborate tables of analyses of soils to show the chemical composition of those most favorable to the culture, but we will here give the more succinct tables of Champion and Pellet,‡ showing the composition of soils from different departments in the north of France in which beet-root culture is most extensively carried on, and and of one from a similar section of Russia. Those numbered 1, 2, 3 yielded beets of fair quality, containing 12 to 14 parts of sugar per 100 of juice, while that numbered 4 gave beets of bad quality. The last, that from Russia, is quoted by Walkhoff as being well suited to beet culture.

* Guide Pratique du Fabricant de Sucre.

† Guide Pratique du Fabricant de Sucre.

‡ La Bettrave a Sucre, p. 82.

	1. Somme.	2. Nord.		3. Aisne.	4. Somme.	5. Katinof-ska soil.
Organic matters	5.600	4.42	4.840	5.70	8.200	6.207
Silica	81.800		82.500	79.00	42.000	72.699
Alumina	7.240		8.620	8.50	3.91	9.974
Lime	0.570	0.476	0.420	0.25	23.220	1.930
Peroxide of iron	2.880		2.180	5.50	2.310	2.854
Phosphoric acid	0.070	0.008	0.077	Trace	0.385	0.093
Potash	0.064	} 0.130	0.140	} Trace	0.044	2.047
Soda	0.085				0.058	0.914
Carbonic acid	0.400	0.600	0.700	} 2.85	19.050	1.280
Other matters	1.351		1.523		0.823	2.022
	100.000	100.000	100.000	100.000	100.000	100.000
Total nitrogen	0.088	0.140	0.120	0.154	0.270	0.234
Ammonia	0.013	0.040	0.030	0.016	0.010	
Sand	72.100	85.000	80.000	62.000	35.770	
Clay	22.000	9.000	14.000	30.000	10 to 12	

"The same authors quote Schübler as giving the following as the general composition of good soil for beet culture :

Clay	33.300
Siliceous sand	63.000
Calcareous sand	1.200
Calcareous earth, humus	2.500

"We now come to the study of the means employed to supply the deficiencies of plant-food in the soil, due either to the natural condition or the exhaustion by crops, and the influence of the means employed upon the production of rich and valuable roots.

"The general composition of the beet root and leaves is given by Champion and Pellet, as follows: They state that for rich beets the weight of leaves is about 50 per cent. that of the root, and 25 to 30 per cent. that of roots containing 9 to 11 per cent. of sugar.

"The table shows the general composition of leaves and roots of beets containing 15 per cent. of sugar :

	In roots.	In dry matter.	In leaves.	In dry matter.
	Per cent.	Per cent.	Per cent.	Per cent.
Water	74.00		83.50	
Nitrogen	0.40	1.55	0.38	2.30
Ashes	0.80	3.10	4.35	26.20

"For a yield of 20 French tons* of beets and 10 French tons of leaves per acre, there would be removed from the soil :

	Nitrogen.	Total ashes.
	Pounds.	Pounds.
20 tons roots	178.1	356.2
10 tons leaves	84.8	934.1

*2,200 pounds.

“Or, for an average richness of 11 per cent. of sugar:

	In roots.	In dry matter.	In leaves.	In dry matter.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Water	22.00		84.10	
Nitrogen	0.25	1.39	0.38	2.45
Ashes	0.95	5.30	3.85	24.8

“Or, for a yield of 20 French tons per acre:

	Total nitrogen.	Total ashes.
	<i>Pounds.</i>	<i>Pounds.</i>
20 tons roots	110	418
6 tons leaves	50	508.2

“The composition of the ashes of the leaves and roots referred to 1,000 parts green matter is as follows:

	Beets supposed to contain 10 per cent. sugar.		Beets supposed to contain 15 per cent. sugar.	
	Leaves.	Roots.	Leaves.	Roots.
Potash	9.23	2.93	10.0	2.66
Soda	3.23	0.51	3.47	0.45
Lime	3.50	0.42	3.75	0.38
Magnesia	2.81	0.38	3.03	0.33
Chlorine	3.23	0.57	3.47	0.50
Sulphuric acid	1.50	0.22	1.63	0.19
Silica	0.31	0.34	0.33	0.30
Phosphoric acid	2.23	0.59	2.40	0.51
Undetermined	2.03	0.16	1.92	0.13
Total mineral matters	28.07	6.12	30.0	5.45
Total solids	138.0	167.5	140.0	240.0
Nitrogen	3.3	2.5	3.8	4.0

“From these figures we may easily determine the quantity of the different constituents removed by average crops. Supposing the average to be 20 tons of roots per acre, the consumption of the different constituents would be, for beets of differing richness, as shown in the following table:

	For beets contain- ing 10 per cent. sugar.		Total.	For beets contain- ing 15 per cent. sugar.		Total.
	Six tons leaves.	Twenty tons roots.		Ten tons leaves.	Twenty tons roots.	
Potash	121.8	128.9	250.7	220.0	337.04	117.04
Soda	42.6	22.4	65.0	76.34	96.14	19.8
Lime	46.2	18.48	64.68	82.50	89.22	16.72
Magnesia	36.1	16.72	42.82	66.66	81.18	14.52
Chlorine	42.6	25.08	47.68	76.34	98.34	22.0
Sulphuric acid	19.8	9.68	29.48	35.86	44.22	8.36
Silica	4.09	14.96	19.05	7.26	20.46	13.2
Phosphoric acid	29.43	25.96	55.39	52.80	75.24	22.44
Undetermined	26.79	7.04	33.83	31.24	36.94	5.70
Total	369.41	248.32	628.50	651.00	888.18	239.78
Dry matter	1,821.6	7,370.00	.....	3,080	.....	10,560
Nitrogen	43.56	110.0	.....	83.6	.....	176.0

"In France the general sources of supply of the various nutritive principles for the restoration of those removed by the crops, or to provide those required, are found in stable manure, seed cakes, animal wastes, woolen scraps, sulphate of ammonia, nitrates, superphosphates made from bones and minerals, potash salts, gypsum, and the scums and refuse from the sugar factories. Of all these substances, that which combines in itself in the highest degree all the elements of plant-food, and which is naturally the most economical, is the stable manure produced on the farm, and this being generally the result of keeping cattle to be fed upon the pulps from the factory is one of the sources of real profit to the producer.

"Joulie gives the following as the composition of French stable-manures of average quality, estimated in pounds per ton of 2,000 pounds:

	Manure of fifteen oxen.	Manure of ten cows.
Water	1,492.576	1,398.656
Organic matter	406.044	476.928
Mineral matter	101.380	124.416
Total	2,000.000	2,000.000
Nitrogen:		
Nitric	0.000	0.000
Ammoniacal	1.880	1.334
Organic	11.822	11.950
Total	13.702	13.284
Phosphoric acid	5.288	3.142
Sulphuric acid	3.010	2.000
Chlorine	2.740	4.000
Potash	19.104	20.872
Soda	5.164	6.284
Lime	14.538	14.060
Magnesia	3.770	3.478
Oxide of iron	1.304	1.250
Sand and silica	39.888	60.913
Carbonic acid and loss	6.574	7.438
Total	101.380	124.416

"A comparison of this table with that given before will show that in order to supply in stable manure the required nitrogen and phosphoric acid for the production of an average crop of 20 tons per acre, it will be necessary to apply at least 20 tons of stable manure to the same area. But this quantity will contain a considerable excess of alkaline matters over the quantity demanded by the crop, and will only tend to increase the saline constituents of the root at the expense of the sugar. This excess of mineral matters is often used to explain the production of roots of low saccharine value. Let us bring together the figures for the constituents of plant-food mentioned, as found in 20 tons of stable manure from cows and as found in the yield of an acre giving 20 tons of beets:

	Manure.	Beet crop.
	<i>Pounds.</i>	
Nitrogen	265.680	259.6
Phosphoric acid	62.849	75.24
Potash	417.040	337.04
Soda	135.680	96.14
Lime	281.200	89.22

"In practical work, therefore, it is found better to reduce the quantity of stable manures applied, and to supplement them with the other substances mentioned above. A comparison of the productive influences exerted by stable manures and by the artificial compounds usually employed to supplement it, or as substitutes for it, will be found in the following table, showing the results of the experiments made by Professor Deherain at the Grignon agricultural school, working with the Vilmorin improved race of beets. These results are interesting as showing the advantage of moderate applications of stable manures, and the choice that should be made in the supplementary compounds that should be applied:

*Influence of manures on yield in weight and richness in sugar.**

No. of the plots.	Manure distributed per acre.	Yield per acre.	Sugar in juice.	Sugar produced per acre.
		<i>Tons.</i>	<i>Per cent.</i>	<i>Pounds.</i>
1	9 tons stable manure	9.2414	12.67	2,351.80
2	18 tons stable manure	8.9893	12.58	2,228.60
3	36 tons stable manure	8.4378	11.28	1,896.59
4	36 tons stable manure and 890.7 pounds superphosphate of lime	8.7220	12.26	2,137.78
5	Without manure	6.1980	14.58	2,257.04
6	356 pounds nitrate of soda, distributed in one sowing	8.4378	12.75	2,184.01
7	356 pounds nitrate of soda, distributed in four sowings	8.7660	12.75	2,234.79
8	356 pounds nitrate of soda and 356 pounds superphosphate, in one sowing	9.1220	13.23	2,415.46
9	356 pounds nitrate of soda and 356 pounds superphosphate, in four sowings	9.9235	13.08	2,568.24
10	1,068 pounds nitrate of soda, distributed in four sowings	8.5230	12.43	2,367.40
11	356 pounds sulphate of ammonia, distributed in one sowing	8.4378	13.89	2,336.25
12	356 pounds sulphate of ammonia, distributed in four sowings	7.7985	12.75	1,962.45
13	356 pounds sulphate of ammonia and 356 pounds superphosphate, in one sowing	6.5860	13.08	1,722.15
14	356 pounds sulphate of ammonia and 356 pounds superphosphate, in four sowings	6.9360	13.08	1,827.17
15	356 pounds superphosphate without nitrogen or manure	7.5205	13.24	1,990.93
16	1,068 pounds sulphate of ammonia, in four sowings	6.4970	12.42	1,693.57

“Joulie* also found, in his experiments with stable manure and the different fertilizing compounds made according to his formula, that the largest yield was obtained with the complete manure containing all the leading elements. The next best yield was secured with the complete manure without potash; the next with nitrate of soda alone. The yields with the others decreased regularly in the order in which they are named. Without phosphate and without lime; with sulphate of ammonia; with stable manure; with nothing; with guano. From his experiments he concludes as follows:

“(1) The manure especially suited to the beet, and and which establishes the best conditions, as well for the yield per acre as for quality, is the complete manure B, of which the following is the composition:

	Per cent.
Nitric acid.....	6.500
Phosphoric acid, { assimilable } { insoluble }	6.500
Potash.....	8.000
Soda	9.000
Lime	14.800
Water, sulphuric acid, silica, and other accessory elements.....	55.200
Total.....	100.000

The nitrogen corresponds to ammonia..... 8.000

The phosphoric acid corresponds to tricalcic phosphate..... 14.200

“(2) In soils provided with potash it (the manure B) is advantageously replaced by the manure F,† which differs only in the substitution of soda for potash.

Denomination of manure.	Nitrogen.			Phosphoric acid.			Potash.	Soda.	Lime.	Access-ory ele-ments.
	Ammo-niacal.	Nitric.	Total.	Assim-ilable.	Insol-uble.	Total.				
Manure A complete.	4.14	2.36	6.50	5.00	1.50	6.50	8.00	.....	17.00	62.00
B complete.	.....	6.50	6.50	5.00	1.50	6.50	8.00	9.00	14.80	55.20
C complete.	.....	4.00	4.00	5.00	1.50	6.50	14.00	.....	19.00	56.50
D complete.	.....	2.50	2.50	8.00	2.50	10.50	8.00	.....	20.00	59.00
E without potash ...	6.50	.....	6.50	5.00	1.50	6.50	.....	.....	19.50	67.50
E concentrated	9.00	.....	9.00	9.00	2.00	11.00	.....	.....	12.00	68.00
E without potash No. 2	3.00	.....	3.00	14.00	2.00	16.00	.....	.....	22.00	59.00
F without potash ...	.....	6.50	6.50	5.00	1.50	6.50	.....	14.00	15.80	57.20
G without nitrogen .....	.....	.....	.....	5.00	1.50	6.50	10.00	3.00	20.00	60.50
G without nitrogen No. 2 .....	.....	.....	.....	12.00	2.00	14.00	5.00	1.50	20.00	59.50

* Guide pour l'achat et l'Emploi des Engrais Chimiques, pp. 250 and 251.

† The conclusions of Professor Joulie will be better understood if reference is made to the accompanying table, showing the composition of the fertilizers, made according to his various formulæ.

"(3) These two manures should be applied at the rate of 400 pounds per acre upon soils in good condition and without stable manures.

"(4) Stable manure, applied at the rate of 20 to 25 tons per acre in the same year that the crop is grown, constitutes a bad condition, which it is prudent to avoid. It is better to reduce the stable manure to 10 or 12 tons and supplement it with a suitable addition of chemical manures. Thus putting the minimum of salts, particularly of potash, at the disposition of the roots, a better quality will be obtained.

"(5) If stable manure be applied at the rate of 10 to 12 tons per acre, which rate it has been found advisable not to exceed, the manure F without potash should preferably be employed at the rate of 200 pounds for good soils and of 400 pounds for poor soils. We thus avoid excess of potash, and establish between the useful elements an equilibrium favorable to the crop.

"(6) If fossil phosphates have been added to the stable manure after the method suggested by Baron P. Thenard, the manure F may be replaced by nitrate of soda at the rate of 260 pounds per acre for good soils and a maximum of 350 pounds for poor soils.

"(7) In no case should salts of potash (nitrate, sulphate, or chloride) be added to stable manure, which is always sufficiently rich in this element.

"From these and later experiments Mons. Joulie concluded, in general, concerning nitrogen of various compounds in its relation to the beet root and the influence upon its sugar content, that the nitrogen of the nitrates is more effective than that of ammonia, which in its turn is more valuable than that of organic matter.

"This difference in the elements of plant-food has also been noticed and determined by other workers, who have arrived at conclusions quite as marked as those of Joulie just given. Pagnoul* states that experiments made at Arras and elsewhere lead to the following conclusions concerning the use and abuse of nitrogenous compounds:

"(1) Abuse of all nitrogenous compounds, nitrates, stable-manures, seed-cake, etc., is always injurious to the quality of the beet.

"(2) Excess of nitrates by application before sowing is less injurious than excess of nitrogenous manures of organic origin. In fact the first are at once absorbed by the young plant favoring the development of leaves. On the contrary, the others act slowly and in decomposing may undergo nitric fermentation, which, favored by meteorological conditions, such as probably existed in 1875 to 1876, creates in the soil an abundance of nitrates, the retarding action of which impoverishes the root in the last days of growth.

"Concerning stable-manure, it is a fact that there is no necessity for prohibiting its use, because growers are generally wanting in it, and they will not be tempted to use it in excessive quantity to the same extent as they may be induced to use the mineral manures. But it is useful to show that this excessive use, if it were possible, would be even more fatal than the use of nitrates, as regards the quality of the root.

"(3) For the same reason the use of nitrates after sowing, and especially in the months of August and September, is absolutely bad, and may be characterized as fraudulent.

"(4) The abuse of nitrogenous manures, nitrates, and others is much less fatal when used upon rich varieties, and roots closely planted than upon poor varieties and roots cultivated at greater distances.

"(5) The causes to which the bad quality of the beets in our region (department of Pas-de-Calais) should be attributed are * * * the too great richness of our soils in nitrogenous matters, the abuse of manures, and the application of nitrates after sowing.

"Concerning stable-manures and the other nitrogenous manures used, M. Georges,* in a lecture on beet-root culture, advises that the quantity of stable-manure should not exceed 10 to 15 tons per acre, since this quantity will supply sufficient of salts for the needs of the plant. Nitrogen being the deficient constituent, should be supplied by some very soluble and easily-assimilable compound, such as from 250 to 350 pounds per acre of nitrate of soda, with an addition of a like quantity of superphosphate of lime, the latter element especially intervening to increase the richness in sugar. The prejudice against nitrate of soda is unjust. Judiciously applied it is useful. Only its abuse is disastrous, but neither more nor less than the excessive use of all others, and even stable-manure worked into the soil previous to sowing; it hastens the vegetation of the plant at the start and helps it through the first stages of growth. When it is exhausted, the stable-manures, by their slow decomposition, supply the subsequent demands of the plant. But nitrate of soda should not be applied during the growth of the plant, because it may then remain in nature in the adult beet, which will not have time to elaborate it and secure all the useful effect. Sulphate of ammonia, with an equal quantity of nitrogen seems to be less favorable than nitrate of soda, because it is a salt which tends to rise to the surface in the soil, while the other descends to an equal extent. Other matters, such as seed-cakes, woolen wastes, etc., may be substituted for the nitrates, but they should in all cases be worked into the soil before sowing, that they may have time to decompose in advance and may be thoroughly mixed through the entire arable stratum.

"These ideas expressed by M. Georges were reiterated by M. Drouyn de l'Huys,† and express the views of all scientists and cultivators in France. But while all admit the value of the judicious application of the nitrates, it appears also to be the universal opinion that it should be accompanied by the application of a corresponding quantity of the phosphates, which have a tendency to counteract any prejudicial influence that the nitrates may exert by hastening the maturity of the plant and increasing its sugar content. This fact has been very nicely elaborated by Professor Maercker, of Halle, in a lecture lately delivered upon the subject of beet culture, an abstract of which may be found in the *Journal des Fabricants de Sucre*. He says it is a well-accepted fact that strong doses of nitrogenous manures are injurious to the beet crop, in that it increases the weight of the non-saccharine contents and reduces the sugar. The discredit into which the use of nitrates has fallen is due to its abuse and the manner of applying it. The difficulty appeared to be to determine the quantity to use and the best time to apply it. When applied too late it retards ripening. Applied in spring the plants develop vigorously in leaves and root and the period of growth is lengthened. So strongly nitrogenous manures always produce growth.

* *La Sucrerie Indigène*, 1878.

† *Compte-rendu des Séances du Congrès Agricole et Sucrère tenu à Compiègne Mai, 1877.*

"But the sugar-beet must ripen to accumulate sugar within it. Its growth should therefore be arrested to admit of ripening, which late distribution of nitrates prevents. At Magdeburg part is applied in the fall and the remainder before the preparation of the soil in spring. Heavy doses of strongly nitrogenous manures also necessitate heavy doses of phosphoric acid to annihilate the injurious effect of an excess of nitrogen. Phosphoric acid applied in large quantity induces early ripening of the plant. A mellow, permeable, clay soil may receive doses that would be injurious to a cold soil.

"Pagnoul has developed by his researches and observations that phosphoric acid gives varying results. In some soils no appreciable effect can be noticed, while in others its use has been found very favorable, and these differences are attributed to the greater or less proportion of phosphoric acid already existing in the soil. Notes should therefore be kept of the effects of various manures in order to avoid unnecessary expense in their application. M. Decrombecque considers that in all cases the phosphoric acid in the soil should be increased as the nitrogenous principles increase, and Woussen considers phosphoric acid a corrective for the deleterious influences of nitrates, because upon soils where nitrate of soda has been applied in large doses it is only necessary to increase the proportion of phosphates of lime to secure good maturation of the crop which would otherwise remain green.

"Pellet* has advanced some interesting notions concerning the comparative values of the different elements of plant-food in their relation to the production of sugar in the beet, deduced from the study of analyses of different plants obtained by various persons in their experiments. Lawes and Gilbert, discussing the analyses of wheats grown upon the Rothamstead farm, and of French wheats analyzed by Boussingault, conclude that wheat scarcely admits of a change in the composition of its ashes, whatever may be the composition of the fertilizers applied; the same is true of potatoes.

"But Pellet finds that the beet, on the contrary, may grow with equivalent substitutions of the alkalies necessary to the formation of sugar, so that, as shown by the experiments of Joulie, soda may be found in the ash of some beets in the same quantity as potash, while in others the quantity of potash is seven times that of soda. This substitution may also be noticed between lime and potash, but experience shows that though the alkalies may thus substitute each other, and lime, by equivalents, certain other bodies, such as phosphoric acid, will not admit of being replaced. The experiments of Champion and Pellet also show that in all plants we may observe a relation between the total weight of ashes and the special organic matters for which the plant is cultivated. Thus in wheat between the starch and total ash, and in the beet between the sugar and total ash. They construct the following table, showing

* Journal des Fabricants de Sucre, October 2, 1878.

in general that for the formation of 100 pounds of sugar in beets, the roots and leaves in their development must consume—

- 1 to 1.20 pounds of phosphoric acid.
- 5 to 6 pounds of potash.
- 1.5 to 2 pounds of soda.
- 1.5 to 1.6 pounds of lime.
- 1.2 to 1.4 pounds of magnesia.
- 2.7 to 3.5 pounds of nitrogen.

“Excess of all may be present in the soil, but if phosphoric acid be wanting sugar will not be produced, while if lime is wanting it will be replaced by potash or soda or magnesia, and this rule holds good for the other alkalies. The author therefore concludes that 1 of phosphoric acid corresponds to 100 of sugar, while 5 to 6 of potash corresponds to the same amount, and consequently phosphoric is worth 5 or 6 times more than potash in the formation of sugar, if potash replaces no other alkalies; in other words, if a soil be wanting in 60 pounds of assimilable potash per acre, there will be a deficit of 1,000 pounds of sugar, while for the same deficit only 10 pounds of assimilable phosphoric acid need be wanting. Phosphoric acid he considers a non-dominant but indispensable element or base for the formation of sugar in the beet.

“Reasoning from these data, they conclude that without experiment, but by examination of the average composition of the ashes and of the quantity of nitrogen in the plant, and comparing the total weight of the different constituents with that of the given proximate principle to be produced, for instance, sugar in the beet and starch in wheat and potatoes, it is possible, they say, to determine the order in which the elements of plant-food are indispensable for each plant. Thus, for the beet they range: 1, phosphoric acid; 2, lime or magnesia; 3, nitrogen, 4, potash or soda. On the other hand, the order for wheat is: 1, lime or magnesia; 2, potash; 3, phosphoric acid, etc. These are facts of great importance in the economy of providing supplies of plant-food, and they will aid greatly in the selection of the compounds to be employed for the fertilization of various crops.

“From what precedes and what we learn from the long-established practices followed in France in the application of fertilizers to the land on which beets are to be produced, it appears that nitrogenous organic compounds insoluble in water should be worked into the soil a long time in advance of the crop, and that to enjoy a beneficial result from their use they should be distributed at least during the autumn preceding the season of planting, and for stable-manures it is preferable that they be given to a preceding crop, which in France is generally oats or potatoes.

“Stohmann* says it is generally recognized as a rule that the sugar-beet should never be cultivated upon a fresh manure or barnyard manure, because this system of culture gives a large yield in weight, but roots so rich in foreign matters that they can not be worked with profit.

* Journal des Fabricants de Suere, November 20, 1878.

The beet should always form the second rotation when the manure is strong.

"Other organic nitrogenous compounds, such as seed cakes, refuse animal matters, and even ammonia salts, may be applied in the fall or in the very early spring, while the nitrates, which are more soluble, may be applied either immediately before or immediately after planting.

"In no case should the latter be applied during the period of growth, on account of its influence, as shown by numerous experiments, to retard the time of ripening and the consequent maximum development of sugar.

"The quantity of stable manure per acre that may be applied to land to produce the most favorable effect seems in France to be from 8 to 15 tons, according to the character of the soil, and it is generally more profitable to use a smaller quantity and supplement it with nitrates and phosphates. The value of lime in its relations to the beet is no less than for other crops. Its disintegrating influence upon the nitrogenous organic matters is as important as its power to take the place of other alkalies which may be wanting. In fact, on account of this property, many of the most intelligent growers are inclined to use it, and by means of it to avoid in the juice many of the more objectionable soluble salts that the alkalies are likely to introduce. Another important consideration is its low market value, and the convenience of its application. At the same time, deficiencies of the other alkalies in the soil should not be overlooked, and they should be in all cases made up.

"It is scarcely necessary to further call attention to the importance and value of the phosphates in connection with this crop, after all that has been said. They may be applied at all times, and many growers consider it of advantage to distribute small quantities with each working or hoeing. The general method employed, however, is to distribute it in advance of the last plowing, in the course of which latter operation it becomes distributed throughout the entire arable layer. But if applied in the spring, it is considered by many that it should be deposited in the rows with the seed, and M. Derome is of the opinion that 100 to 250 pounds per acre applied in the rows will produce quite as good effects as 400 to 800 applied broadcast. He concludes from all his experiments, the results of which are confirmed by those obtained by Corenwinder, Pagnoul, Ladureau, and others, that artificial fertilizers worked in with the plow will give an average of about 3 tons more of beets than the same quantity of manure applied on the surface and worked in with the cultivators.

"The next consideration in the culture of the beet is the improvement of the physical qualities of the soil, and its preparation for the crop. The importance of drainage, etc., has already been referred to in the review of the inherent physical qualities of the soil which make it suited to this crop, and we may therefore proceed at once to the consideration of its manipulation to bring it to the favorable conditions before quoted.

And we shall first of all review the ideas advanced on this subject by some of the later writers who may be considered good authorities. Briem* says:

“The development of the beet depends, in the first place, upon good preparation of the soil, and its continued and careful maintenance. A preparation carefully effected brings about a mellowing of the soil, access and change of air and water, destruction of weeds, and deep growth of the root. Deep plowing (with steam where this is possible) is the first condition of a rational culture. This operation should be effected in advance of winter. Subsequent cultivation should not be spared. It improves the size and quality of the plant, and should be repeated as often and as long as the leaves will permit. The more the culture approaches that of a garden the more the quantitative and qualitative yield will be increased.

“According to Stohmann, beets do better after well-manured graminæ. They naturally find place in rotation after wheat and barley. In some cases beets have been produced two years in succession, but this is possible only in exceptional cases. It is injudicious to recommend a rotation of beets of less than two years. Immediately after a crop of cereals, the ground is broken up. In the fall, plow as deeply as the nature of the soil will permit, and leave the field with the furrows thus exposed during the winter to atmospheric influences. In the spring, prepare the soil for sowing by means of the roller and harrow; and in order not to lose the accumulated moisture of winter, avoid, as far as possible, plowing again in the spring.

“Vilmorin† directs to begin with an ordinary plow in the fall, followed by a draining plow, so that the ground will be broken up to a depth of 6 to 8 inches; and plow in the spring, and follow with harrow and roller. We can not more clearly give the prevailing opinions of French growers upon this matter of preparation of the soil than is expressed in the discussion on the subject in the meetings of the agricultural and sugar congress held at Compiègne in May, 1877, and published in the report of the proceedings; and I therefore present below a translation thereof:

“M. Boursier said that it is, above all, necessary to work the ground and put it in such condition that it may be at the same time permeable and firm enough to adhere to the roots. This is effected by deep plowing and energetic harrowing and rolling. It would, nevertheless, be useful to elucidate this point, whether it is better to give a single deep plowing in autumn, followed by cultures with the scarifier and the harrow in spring, or to give several plowings, the first in advance of winter and the second immediately preceding sowing. For himself he considered it better to give a single deep plowing in the fall or winter.

“M. Debains prefers the system which consists in first giving a plowing to break up the stubble, followed by another to bury the manure, and finally a third before sowing.

“M. Blin said there was no necessity to have an absolute system with this regard. It would be dangerous to give a deep plowing to land having a shallow stratum of arable soil.

“M. Decrombecque had not adopted deep plowing, for the nature of his soils would

* Journal des Fabricants de Sucre, October 23, 1878.

† *Ibid.*, February 27, 1878.

not permit it; but in order to submit the greatest possible surface of soil to the beneficial atmospheric influences, he practiced the method of ridging.

"M. Boursier explained that by deep plowing he did not mean absolutely to say 14 to 16 inches; plowing is considered deep when it exceeds by 1 or 2 inches that of preceding culture. A plowing of 10 inches would be deep in ground which had never been broken up more than 8 inches; the depth is modified according to the soil.

"M. Demot called attention to the excellent effects of breaking up without displacing the subsoil (*i. e.*, subsoiling). With this system the production is sensibly increased. The use of the draining plow should be strongly recommended.

"M. le Vte. de Chezelle called attention to the favorable effect of deep plowing shown by the vegetation on the sides of ditches opened for drainage.

"M. X. ——— responded that this fact does not constitute an argument in favor of deep plowing. In fact, in drainage the vegetal earth is always returned to the top while plowing brings the subsoil to the surface, and if this is not vegetal (fertile) it is evident that the operation is defective. He also insisted upon the use of the draining plow.

"M. Barral recognized the fact that deepening the arable layer is always advantageous in the long run, and he recommended attacking the subsoil only with precaution, and after taking into account its chemical composition. In this connection, as in the most of agricultural questions, it is impossible to fix an absolute principle, and it is always necessary to take account of circumstances. Besides it can not be denied that the beet is one of the plants for which the depth of the arable layer is of the greatest importance.

"M. de Rougé has proven the excellent effects of deep plowing upon the poor clay soils of the extremity of the Aisne. Like M. Boursier, he counseled plowing in autumn. During the winter the land to be sown in the spring should be impregnated with the substances of the air and submitted to the favorable atmospheric influences. Broad furrows should be made in the first plowings given in autumn, because the more the earth is formed of large lumps the more the frost may penetrate by the wide spaces which separate them.

"M. Ch. Gossin remarks two unfortunate effects in the plowing which immediately precedes sowing the beet. (1) This plowing stirs up the soil in the interior. Now, the beet does not like light soils. (2) By this plowing we bring to the surface a quantity of bad seeds, which germinate at the same time as the beet, and cover the ground with weeds, while if the ground be plowed in the fall, the seeds which germinate in the early spring are killed in the operations of culture which precede sowing. Therefore in the triple regard of contact, of atmospheric agents, of the mellowness and internal cohesion of the soil and cleanliness of the ground, fall or winter plowing should be advised.

"The method of preparation followed in practice by M. H. Vilmorin is as follows: Begin plowing in November and break up the land 8 or 10 inches, and follow this with a subsoil plowing to a depth of 8 or 10 inches more, so that the ground will be thoroughly stirred up to a total depth of at least 15 inches. During the progress of this work, and as far as possible, the artificial fertilizer employed is distributed in the furrows before subsoiling. The ground is then left in the rough condition consequent upon plowing, and after that is twice plowed in spring, in February and April. It is finally prepared for sowing by harrowing and rolling.

"M. Champonnois considers it of advantage to prepare the ground in ridges before sowing, especially in working very shallow soils, in order to provide depth for the long tapering root, and put the ground in better condition for the circulation of air and water. He claims for his

method of culture that it is less costly than the ordinary method, and gives a better quantitative and qualitative result. In his experiments he obtained 40 tons of beets per acre having an average richness of 18.50 per cent. and a co-efficient of purity above 83.

"The results of his experiments in 1878 do not seem to be as good as those obtained in previous years, as shown by the following table:

	No. 1.	No. 2.	No. 3.	No. 4.
Product per acre (tons).....	28.300	40.450	22.500	11.725
Density of juice.....	6°.17	5°.45	6°.75	7°.5
Per cent. of sugar.....	11.37	9.61	14.90	16.91
Quotient of purity.....	69.70	66.69	83.94	86.0

OBSERVATIONS.

No. 1.	No. 2.	No. 3.	No. 4.
Seed, four kinds; richest, 12½ per square meter; fresh manure two months before sowing; earth beaten slightly on April 23, and after the beets had four leaves; complete manure, 200 pounds per hectare; culture given regularly.	Same culture and care; four kinds of seeds productive of weight; at November 1 beets were in full growth due to kind of manure and time of its application; beets short and rooty.	Manure well rotted; plowed in ridges; well beaten by rolling; manure-residues of elution containing salts and nitrogen of molasses; culture regular throughout entire growth.	No manure plowed in; chemical manure, 625 pounds per acre, worked in; sowed late; culture continued throughout vegetation; quality good; quantity wanting, explained by late sowing.

"However, in this matter of preparing the soil, as in all others, it appears that the grower, while following the general principles enunciated, must be guided by his own judgment and the character of the soil with which he has to deal.

"Sowing is generally effected by means of a drill especially designed therefor, but any drill that will deliver the seed regularly and in sufficient quantity will satisfy every purpose. The forms employed in France vary with the different inventions, but the spoon drill is the most common.

"The best time for sowing is considered to be the last week in April and the first fortnight in May, when the temperature should range from 50° to 60° Fahr., for at this temperature the seed will germinate most surely and most rapidly. The germinating faculty is materially increased by immersing it in water at 120° Fahr., and the beets produced are often richer in sugar on account of this treatment.

"Messrs. Champion and Pellet* give the following results of an experiment in growing seeds soaked in water and those not soaked:

	Date.	Average weight.	Sugar in beets.
		Grams.	Per cent.
No. 1, normal seed.....	August 31.....	400	16.4
	September 16.....	460	13.4
	September 29.....	580	17.0
No. 2, soaked seed.....	August 31.....	.....	16.9
	September 16.....	500	14.9
	September 29.....	580	17.2

* La Bettrave à Sucre.

“ Besides this, the beets produced with soaked seed had a better form than those from normal seeds.

“ Various solutions have been suggested to be employed for soaking the seed, among others water slightly acidulated with nitric acid. Humboldt suggested very dilute chlorine water, but Ducharte showed that this was of no value.

“ In many sections of France and Germany the juices flowing from the manure heaps are used for this purpose. They are diluted with an equal volume of water, and the seeds immersed in them for forty-eight hours. The seeds are after this time taken out, mixed with ashes, and passed over a screen. After this treatment they may be put in bags and kept in a cellar or other cool place until needed. When ready to be sown they must be quite dry on the surface, in order that they may not adhere to each other in sowing. Other solutions for the purpose have been used in France and Germany, the values of which, Basset† states, range in the order in which they are named:

“ 1. Mixture of urine and water in equal parts.

“ 2. *Purin*, or manure juices, pure or dilute, for which may be substituted ordinary water in which has been macerated guano, fowls' or pigeons' dung, so as to obtain a solution of a density of 1.015 or 1.020.

“ 3. Solution of nitrate of potash of 5 per cent.

“ 4. Solution of phosphate of ammonia of 2° B.

“ 5. Solution of superphosphate of lime 2 per cent.

“ 6. Solution of 2 to 2.5 parts chloride of lime in 100 of water.

“ 7. Dilute acid solutions of 1 to 1½ per cent., prepared only with hydrochloric, sulphuric, or phosphoric acids.

“ Solutions of nutritive matters are considered more favorable to the purpose than pure water, because the latter in prolonged soaking will often remove from the seeds some of their soluble constituents. The length of time during which the soaking should be continued might vary somewhat, according to the temperature, but it is generally confined to forty-eight hours, and twenty-four are often considered sufficient. Basset states that during twenty-four hours seeds will absorb—

69 per cent. their weight of water at 39.9° Fah.

91 per cent. their weight of water at 50.8° Fah.

95 per cent. their weight of water at 60° Fah.

97 per cent. their weight of water at 65° Fah.

“ Experiment has shown that seeds require, in a soil sufficiently moist and aerated, a total sum of degrees of average temperatures equal to 650° Fah. for germination. Thus if the average daily temperature be 50°, thirteen days will be required for germination; if it be 55°, then twelve days will suffice; and if 65°, only 10 days will be required. If, however, the seed be soaked for twenty-four hours in water at 100°,

† Guide Pratique du Fabricant de Sucre.

then the total sum of thermometric degrees, and consequently the number of days required for germination, will be correspondingly reduced. If they be soaked forty-eight hours at 100° , then only nine days will be required for germination in the ground at an average temperature of 50° , and a correspondingly less time with a higher temperature.

"With regard to the best time for sowing them, Basset* directs as a rule: *"Sow as early as possible according to the temperature of your locality, whatever may otherwise be the method chosen."* Thus, when the temperature of the air is from 50° to 54° Fah. at noon, 46° to 50° in the evening, and 32° to 36° in the morning, sowing may be begun without fear of unfavorable temperature. This may be combined with observations of the temperature of the soil, which should at the same time have an average of about 45° at a depth of 4 to 6 inches.

"Concerning the depth to which the seed should be covered in the ground, opinions differ somewhat, but it will naturally follow that much must necessarily depend upon the temperature of the season, the physical condition of the soil, and the proportion of moisture. The seed requires the presence of oxygen for germination, and, therefore, if the penetration and circulation of atmospheric air be rendered difficult or impossible on account of a close, hard character of the soil, this function can not be exercised, and the seed will rot in the ground. If the soil be permeable and contain sufficient moisture, the depth of covering the seed will vary with the temperature. If this be too low, again, the seed will rot. But with a favorable temperature and a good physical condition of the soil, less attention may be given to the depth of seeding. However, it is considered a good rule not to bury the seed under any circumstances more than 1 to 2 inches, and experience has shown that at this depth, other things being equal, a higher percentage of the seeds will grow than at any other.

"In all of the beet-growing districts of Europe the system of planting in rows has been adopted, but in later years the attention and experiments of the progressive men have been directed to the determination of the influence of the distance between the rows and the beets in the rows upon the yield per acre and the saccharine value of the crops. In earlier years the practice was to separate the roots to such an extent that each square yard of surface should be devoted to six roots, but the experience of later years has shown that it is better to increase the number for this surface to ten. The extent of separation must naturally vary with the character of the soil and the seed grown. If in rich soils the roots be widely separated from each other they have at their disposition more of nutritive materials, and there is, of course, a tendency to the production of large roots, which, we have seen, will contain more of mineral and organic impurities and less of sugar. On the other hand, if grown more closely the stock of nutriment is less, the beets are smaller

* Guide Pratique du Fabricant de Sucre, p. 387.

and longer, and consequently richer. Yet, notwithstanding the smaller volume of the beet produced, the weight of the total yield per acre is very much larger than when the roots are separated to greater distances. These facts are amply illustrated in the results of the experiments of various workers in the sugar-growing districts of France.

"The following table shows the averages of the results obtained from experiments made by the Société d'Agriculture de Compiègne in concert with the Comité des Fabricants de Sucre de l'Oise. This recapitulation is made simply according to the separation, and without regard to the fertilizers employed.

[Distance between the rows, 18 inches.]

Distance between beets in the rows.	Beets per acre.	Average weight of a beet.	Density of pure juice.	Per hundred of juice.			Degree of purity.	Saline coefficient.	Sugar per acre.
				Sugar.	Salts.	Organic matters.			
	<i>Tons.</i>	<i>Pounds.</i>	<i>Degrees.</i>						<i>Pounds.</i>
Ten inches.....	32, 533	1. 88	6. 79	14. 55	1. 0823	2. 0910	81. 93	13. 58	8, 473
Fourteen inches.....	29, 515	2. 23	6. 06	12. 68	0. 8195	2. 2976	80. 19	15. 61	7, 480
Eighteen inches.....	31, 048	2. 85	5. 05	12. 40	0. 8700	1. 0142	86. 71	14. 43	6, 691

"Pagnoul's experiments, conducted during a series of eight years, gave similar results. He concludes that close planting gives beets which are (1) richer; (2) better quality; (3) of larger yield in weight; (4) less exhausting to the soil. He took, for his wider separation, 20 inches between the rows and 20 inches between the roots in the rows, and for the smaller separation 17 inches between the rows and 8 inches in the rows.

"(1) The richness of sugar in percentages of the weight of root was:

For the large distances.....	10. 2
For the small distances.....	12. 2

"(2) The proportion of alkaline salts, giving at the same time the measure of the foreign organic matters, was for 100 of beet:

With large distances.....	1. 512
With small distances.....	0. 722

"(3) With large distances there were 16,326 roots per acre, and with the small distances 46,122, or nearly triple. The yield in weight per acre was:

	<i>Tons.</i>
With large distances.....	28. 035
With small distances.....	36. 045

"(4) The quantity of salts removed per acre would be equal in round numbers to:

	<i>Pounds.</i>
With large distances.....	840
With small distances.....	520

"M. Pagnoul says in conclusion:

"Beets at small distances, while producing more of sugar, absorb less of saline matters.

"Now we know that the constituent principles of sugar are entirely furnished by the atmosphere, and that the saline matters are furnished by the soil and by fertilizers; therefore, *beets at small distances from each other (i e., closely planted) are less exhausting to the soil.*

"Close culture is more profitable at the same time to the grower and the manufacturer.

Dubrunfant says:*

"The multiplication of subjects to avoid large roots, and to facilitate at the same time the production of a good constitution of the cellular tissue, is another condition to which great importance should be attached in the interest of richness in sugar.

"Briem says† 'the separation of the roots should be 15 by 10 inches.'

"In a late discussion in the meeting of the Cercle agricole du Pas-de-Calais,‡ it was developed that though the distance of 17 inches between the rows was still in use, it is gradually giving way to the wider separation of 20 inches, on account of the difficulties experienced in horse-hoeing and the deficient æration of the improved races of beets with strong foliage, which require more room.

"At the same time that the wider distance between the rows is adopted the roots are left closer to each other in the row about 8 inches; that is to confine them to from seven to nine roots to the square yard of surface.

"The experiments of M. Pagnoul, and results he obtained, together with the other facts and figures given, will be sufficient to show the importance of this matter of close planting, without quoting the results of the same character obtained by Corenwinder, Ladureau, Mariage, Pellet, Deherian, Vilmorin, and others; and we may conclude that for the methods of culture that must be employed in the United States where hand labor can not be obtained, the wider distance between the rows, 20 inches, should be adopted, separating the roots not more than 8 inches in the rows.

"The cultural manipulations proper of the crop should begin as soon as the beets are up and the leaves sufficiently developed to distinguish the rows; and we may accept the statement so universally reiterated by those who speak and those who write on the subject, as supported by the success of the practice, that 'early and frequent cultivation can not be too strongly recommended; it kills weeds scarcely started and forms a stratum of mellow earth which constitutes an obstacle to dryness by day and assimilates the moisture of the night.'

"As before stated, as soon as the rows are defined by the development of leaves the first cultivation by hoeing begins.

"In France this is, in many sections, performed by hand, while in others it is effected by means of the horse cultivator, the object being, of course, the destruction of weeds and stirring up the soil. At this time, also, many growers make an application of nitrate of soda or

*La Sucrerie Indigène, xiii, 460.

†Journal des Fabricants de Sucre, October 23, 1878.

‡Ibid., June 4, 1879.

potash. Two weeks later the beets are thinned out, so as to leave the roots about 8 inches apart from center to center, after the manner described above. After this the crop receives about three hoeings or cultivations, and more than this if time allows, for the work should be discontinued about the 1st of July, according to some authorities, or it may be continued as long as the leaves will allow, according to others. The latter will probably be for all localities and climates the better indication.

"After the final hoeing, about the 1st of July, no other care is necessary, with the exception of the removal of seed-stalks that may occasionally appear, especially if July and August be dry, until the harvesting, which should take place before the appearance of hard frost. If the roots be frosted in the ground they are rendered unfit for storing and preservation in caves or trenches for extraction of the sugar in the late winter, which is, of course, often necessary.

"Harvesting is generally begun about the middle of September, and may, according to the condition of maturity of the crop, continue until the middle of October.

"Pulling the roots is sometimes effected by machines that have been devised for the purpose, but the method generally employed is hand-pulling, the latter facilitated by the assistance of the pick or plow. In many cases a narrow furrow is made near to the row, which loosens the earth about the root and renders its extraction from the ground easier. The operation must in all cases be exercised with great care, in order that the roots be not bruised or cut, accidents which increase the tendency of roots to decay when stored. They should also be pulled when the ground is in the driest condition. If the ground be wet at the time of pulling, the earth will adhere to the root, and this will also produce a tendency to decay. Besides this, trouble will arise in the determination of the tare in the delivery of the crop to the manufacturer. In most cases the leaves are removed from the beet in the field, either at the time of pulling or at the time of charging them to the carts or wagons in which they are to be transported, either directly to the factory or to storage. If there be danger from the frost the roots are piled in pyramidal heaps, either before or after the removal of the leaves, in such a manner that they may be covered by their leaves or by straw. The leaves are removed by a knife or other instrument sufficiently strong and heavy that the operation may be effected at a single stroke. It is estimated that twenty laborers* (women and children) will be required to pull and prepare for transportation from the field the crop of an acre of beets in one day.

"But this estimate is made for French laborers, and we may calculate

* In the department of Seine-Inférieure ten laborers are generally employed for pulling the crop and preparing for transportation, five to pull the roots, and five to remove the leaves and tops.

that only half the number of laborers will be required in the United States to do the same amount of work.

"The beets to be preserved, if all surface moisture has not already evaporated from them, should, before being placed in trenches or cellars, be temporarily stored under sheds. Here the wounded, withered, or frosted roots, which would be subject to rot, are separated, if they have not already been in the field. The larger roots are also separated for the same reason. When thus separated and prepared they are ready to be stored. In the preservation the conditions to be avoided are too low or too high a temperature, too moist or too dry an atmosphere. With too low a temperature they deteriorate by freezing. This is not so injurious if the roots can be worked before they have an opportunity to thaw; otherwise, much of the cane-sugar changes over to inverted sugar, and must necessarily pass into the wastes in the processes of extraction. If too warm, similar effects will be produced by growth of leaves, as shown by Corénwinder and others. If too much moisture be present the roots have a tendency to rot, and if too little be present there will be a tendency to wither, and this effect is always accompanied by a loss of sugar, besides increasing the difficulty of extracting the juice from the root.

"The best temperature for preserving the roots in the fresh state, which is the condition of preservation most employed in France, is between 35° and 40° Fah. The equilibrium of moisture between the air and the root should be so maintained that evaporation may not take place; at the same time, as before stated, excess of moisture must be scrupulously avoided. Prudent cultivators consider that the roots should be so arranged in storage that they shall never be more than 3 feet from an air passage, in order to secure constant and regular renewal of the air to carry off noxious gasses, superfluous moisture, and regulate the temperature which always has a tendency to rise. The cellars or trenches must also be thoroughly drained, so that any water that may collect in the bottom may flow off. Temporary trenches are often made in the fields, but the more advanced growers are preparing permanent ones with well-paved bottoms and walled sides. They are generally 8 to 10 feet wide and 6 to 8 feet deep. I have seen them with walled sides 9 by 9 by 35 feet.

"Along the bottom of the ditch and through the middle of it is made a small trench to convey any water that may percolate through the walls or through the roots. Before the beets are placed in the trench the bottom is covered with poles, or in any other convenient manner, to keep the roots off the bottom and provide for free circulation of air under them and drainage of water. Straw is often used for this purpose, but is considered bad, because it is subject to packing and decay, and the latter will, of course, be communicated to the stored roots. They are then packed in the trench and covered with straw or leaves and finally with

earth. The depth of covering must be determined by the climate. In the case of permanent walled trenches, which amount in reality to elongated cellars, I have seen them covered with a very thick thatch of straw, proper openings being provided for the necessary ventilation. In this way the roots may be preserved throughout the entire winter. If they should by accident be frozen they should be preserved in this condition until they are worked. Indeed this condition constitutes one of the modes of preserving them where a sufficiently low temperature may be maintained to keep them in this way unchanged without an opportunity for thawing, and is recommended by some authorities. In sections where excessively cold winters prevail it might be found a very convenient method for the purpose.

“Desiccation may be practiced where the method of diffusion or maceration has been adopted as the means of extracting the juice. It has the advantage of preserving the beet perfectly, with no danger from variations of temperature if the product be kept free from moisture or a moist atmosphere. They are also in the most favorable condition for ready transportation to any distance.

“For the purpose of drying, the roots are cut in slices, and in warmer climates placed in the sun, but in ordinary climates they are dried in ovens by artificial heat. The method has the disadvantage of requiring a double expenditure of fuel in evaporation, *i. e.*, for the removal of the water of vegetation and the water of diffusion employed for extraction of sugar.

“We see therefore that the experience of French growers and scientists proves that to secure the greatest profit from the culture of the beet the following points must be observed :

“Choose well-drained permeable soils, not overcharged with nitrogenous organic or soluble mineral matters. Choose the best qualities of seed. Give preference to smaller seeds. The best beets for all purposes are long, tapering, and smooth ; do not grow out of the ground ; are of moderate size and are dense and heavy. Plow deeply and as frequently as may be necessary to make the soil mellow. The more it approaches that of a garden in physical condition the more favorable it will be for culture of the beet.

“Be careful in choice of manures to be employed. Remember that insoluble and not easily assimilable nitrogenous organic compounds, before they can be of use to the crop, must be thoroughly disintegrated and decomposed. They must therefore be applied sufficiently in advance of the crops to secure this effect. Soluble nitrogenous compounds may be applied immediately in advance of or simultaneously with planting, and of these the nitrates are preferable. Nitrogenous compounds have a tendency to extend the period of growth and delay the time of ripening. This tendency is counteracted by the phosphates, in consequence of which they increase the production of sugar.

“Stable manures must in all cases be worked into the soil with the fall

plowing. Do not apply more than 10 to 15 tons per acre, and supplement it with nitrate of soda and superphosphate of lime at the rate of from 200 to 400 pounds of each per acre, according to the character of the soil.

"Alkaline salts should be applied with great caution, and only to soils manifestly wanting them. They add to the cost of culture, and often reduce the industrial value of the crop. Plant closely; 18 to 20 inches between the rows will be found the most convenient and favorable for culture in the United States. Separate the beets by about 8 inches in the row.

"Cultivate early and often, and continue as long as the leaves will permit, but not longer than the middle of July. Do not harvest until the crop is thoroughly ripe, but it must not be allowed to be injured by frost.

"Store the roots in such a way that they may be protected from extremes of temperature and moisture, and observe care in ventilating trenches or cellars; otherwise the roots will rapidly deteriorate."

FERTILIZERS.

In respect to fertilizers, Stammer makes the following observations:*

"Manuring should first of all give back to the soil what the harvest has removed, both as regards mineral substances and nitrogen. Nothing can be more certain than that a soil to which this restoration is not fully made will gradually lose its faculty to produce plants in normal quantity and composition. Culture experiments with artificial food liquids have not been carried so far with the beet as with some other plants and, therefore, the dependence between the composition of such liquids and the evolution of the beet has not yet been determined. The basis is also wanting whereon the direct working of the manure on the beet can be predicted; and here is met the well known difficulty of getting the manures into those layers of the soil from which the beet chiefly draws its supplies

"From the present stand-point of our knowledge, therefore, the chief object of fertilization is the preservation of the favorable nature of the soil for beet culture.

"After what has been said it will not be matter for surprise that the numerous and laborious fertilization and cultivation experiments with beets have hitherto produced no generally applicable results; such can only be expected from the laws which will be established by the artificial cultivation of the beet in known nutrient solutions, and it is by no means a contradiction of this fact that the beet farmer should be advised to undertake fertilization experiments upon his particular soil. It is only a matter of ascertaining the particular form and quantity of

* Stammer *op. cit.*, pp. 170 *et seq.*

fertilizer which will best give necessary restitution under the local conditions, and such a form will doubtless in many cases be found, but it will be seldom possible to obtain from it a certain and constant influence upon the crop. The influence of those factors, over which we have no control—climate and weather—is always more powerful than the slight alterations which can be made in the character of the soil by the restitution of the elements taken from it, or by the preservation of the good character of the soil by fertilization.

“Since experience has taught that beets raised on fields freshly manured with stable manure are inferior for purposes of manufacture, the rule has long been established that not the beets, but the previous crop should be fertilized, or that the beets should be raised in rotation as the second or even third crop. Unfortunately this rule, so important to the factories, has not been so generally observed of late, and as a consequence of heavy manuring heavy crops have been produced, but at the cost of diminished sugar content or lessened price. This rule applies especially to stable manure and night-soil, as well as for Chili saltpeter, the misuse of which has had such serious consequence for factories, but not for phosphatic manures, which usually exert a favorable influence upon the crop.

“The constituents which are especially to be taken into account in the necessary restitution to the soil for beets are potash, phosphoric acid, magnesia, and nitrogen. Following are the quantities of these constituents contained in 1,000 pounds of beets and beet leaves, as given by averages from numerous analyses:

Constituents.	Roots.	Leaves.
	<i>Pounds.</i>	<i>Pounds.</i>
Potash.....	3.3	6.5
Phosphoric acid.....	0.8	1.3
Magnesia.....	0.5	3.0
Nitrogen.....	1.6	3.0
Total ash.....	7.1	18.1

“It will be seen from the relation between the roots and leaves that the amounts abstracted by the latter is considerably greater and deserves especial consideration in case the leaves are not left in the field. From this point of view the extensive practice of paying for the work of digging with the leaves is to be considered an evil and should be condemned. It is certain that a complete restitution can not be made in such fields. * * * The form in which the above mentioned plant constituents shall be returned to the soil is established for phosphoric acid and magnesia, and partly for nitrogen; superphosphates, with greater or less content of phosphoric acid, or with addition of nitrogenous element, are of universal application. The magnesia is returned in the press-cakes, as has been shown by direct investigations, pretty completely, though a more uniform distribution is much to be desired, which

can be improved by thorough subdivision. It is advisable to institute investigations from time to time in regard to the phosphoric acid, and especially the magnesia in the waste products, and use them according to the results obtained.

"The question of returning the potash abstracted is more difficult; its computation is complicated by many uncertainties which can not be entirely avoided. Still this should not prevent the return of at least the difference between the potash in the entire crop and that contained in the refuse as nearly as it can be ascertained. Potash fertilization has largely fallen into disrepute chiefly because large and definite returns are expected from it, whereas the principal effect is to be expected in the *preservation* of the crop-producing qualities of the soil. These will surely suffer a decrease sooner or later in the succession of seasons if the restitution is not complete. A change can doubtless be expected when it is possible to fertilize the subsoil. Then for the first time will it be possible to judge of the direct influence of potash fertilization on the beet. A broader question, however, and one that may essentially influence the results in the case just mentioned, lies in the form of the potash compounds to be used, which is likewise true of the other fertilizing materials. There is scarcely a single point on which the views of practical men differ more widely, and new compounds are continually being recommended as the best. Only one rule seems to be of general application, that the potash salt should always be mixed with some common salt in order to insure its reaching the lower layers of soil; also the advantage of admixtures of magnesia salts if these are not given to the soil in some other way. Of the various potash compounds found in natural deposits none deserve preference over the others; this is due only, it seems to me, to compounds with organic substances. To give the reasons for this would require too much space; they will be apparent to the observant student of plant-life. Consequently the molasses, or its residue after distillation or the liquors of the molasses-working processes, all rich in potash, are themselves the most valuable materials for potash fertilization and should be carefully preserved for such use. It must not be supposed, however, that the demand of beet cultivation for potash will be satisfied by returning to the soil the molasses from the crop of beets in the form of waste products. Aside from the leaves, for which if taken from the field a largely increased potash return must be made, the molasses itself does not represent the entire amount of potash taken. Factories which produce raw sugar sell with it also potash, and in all factories the waste waters carry potash compounds, in small quantities it is true, but sufficient to account for the difference between the amount of potash in the beets and in the molasses. This is not simply a theory, but is based upon exact analyses of the factory waters.

"Although factories which sell refined sugar only, and by the purchase of after-products, or of foreign beets, may increase the amount

of potash in their molasses above that taken from the soil in their own beets, and thus be able to make complete restitution by means of their molasses liquors, in most instances the contrary is the case, and to the sources of loss mentioned others must be added.

“That the potash fertilization is not sufficiently accomplished by the return of the molasses waste, however, is no reason why they should not be utilized as the most natural and suitable means towards that end. * * *

“To be sure there are great tracts of beet-fields where this is difficult or impossible, owing to peculiarities of location. For such, as well as for the unavoidable deficit, recourse must be had to potash salts, as must also be the case at first with many estates until an easier plan of molasses fertilization is discovered. Without going into the question as to what potash salt is to be preferred, or why such different results have been obtained from them, I would call attention to the fact that the certain results obtained from molasses-liquor fertilization indicate that the ordinary method of distributing the potash salt on the ground could well be supplanted by the solution of the salts in liquids which are rich in organic substances. It could certainly be expected that the application of, for example, sewage water in which potash salts had been dissolved, would be more likely to secure uniform distribution of the potash in the soil and in a better condition for plant nourishment than the application of small crystals of an inorganic potash compound. The same end can, of course, be attained in other ways. The salt may, for instance, be incorporated either as a fine powder or in concentrated solution with other fertilizing materials in a compost heap, etc. Experience and a few trials will soon indicate the best method.

“The advantages of such a mixture of potash fertilizers with stall liquor (the distribution of the salt in the stalls themselves is recommended by many) are given as follows by Frank :

“(1) The sulphate of magnesia in the potash salt holds the ammonia and the phosphoric acid of the manure.

“(2) Too rapid fermentation of the manure is avoided.

“(3) The prevention of the ammonia vapors arising from fermentation keeps the air of the stable purer and healthier.

“(4) The laborious application of the potash fertilizer is saved, and a much better distribution secured.

“(5) The cost of potash fertilization is cheapened, since the less expensive salt is better adapted for use on account of its content of magnesia.

“(6) The expense of the gypsum, which would otherwise be used, is avoided.

“There are also various methods for the use of molasses liquors ; the simplest, sprinkling from potash casks, has been chiefly used heretofore, although illy adapted for an extensive establishment. The more complete system of underground pipes with the necessary openings in vari-

ous places, as practiced, in England, is excluded on account of its cost. As a consequence the liquors have long been burned, and the slop ashes brought upon the field; but the fertilizing effect was lacking, although the restitution of potash was complete. Another difficulty was encountered in the loss of the nitrogen in the molasses, the value of this being nearly equal to that of the potash content. * * *

"The charring of the liquor is therefore inadvisable on two accounts, and only one resort is left; the evaporation of the liquor to such a degree as will admit of its profitable transportation. True, a very concentrated liquor can not be uniformly distributed on the field and must be further diluted on the spot, or mixed in compost with other fertilizers and thus brought upon the land. But a uniform distribution of the fertilizers, especially one saturated with liquids, demands very careful work.

"The absorption of either the thin or the concentrated molasses liquor by soil has also been productive of good results. But this method can not be universally used. The question of a cheap and uniform method for utilizing the molasses residues has become a very serious one in regard to molasses working, and can only be considered as settled for certain conditions.

"As for the relation which the quantity of material returned should bear to the quantity abstracted, it may be said in general that it is desirable to return as much nitrogen, one and a quarter to one and a half times as much potash, and two and a half times as much phosphoric acid as has been abstracted.

"I will say further that greater additions of potash and phosphoric acid have no disadvantageous effects upon the crop. * * * Direct investigations in regard to the relation between the sugar and potash in consecutive crops for many years have failed to give the least ground for a contrary conclusion. But it must not be expected on the other hand that increasing fertilizations, especially potash fertilization, will produce proportionately increasing crops, as has been asserted by some."

INFLUENCE OF NITROGENOUS MANURES ON THE QUALITY OF THE BEET.

The opinion has generally prevailed among beet-growers during late years that heavy nitrogenous manuring, especially with nitrate of soda, exercised no injurious effect on the quality of the beet. This opinion was based on the fact that in such beets the sugar per cent was only slightly diminished. Nevertheless the quality of a beet may be impaired even with little or no diminution of the sugar content by reason of the increase of the percentage of non-sugars present.

Herzfeld* has shown that heavy manuring with nitrogenous substances greatly injures the quality of the beet for sugar-growing pur-

* Zeitschrift Rübenzucker Industrie, February, 1888, p. 131.

poses. In beets grown at Warmsdorf in 1887 the true co-efficient of the beet was found on unfertilized plots to be 69.2, while on the plots which had received large quantities of nitrogen it was only 65.1. In other words the unfertilized beets require that 31.8 parts of non-sugars must be removed in order to isolate 69.2 parts of sugar; while the proportions for the fertilized beets are 34.9 parts of non-sugar for only 65.1 parts sugar.

In beets from Atzendorf the injurious effects of Chili saltpeter were noticed in all cases; 30 per cent more of the nitrogen present in the beets being in the form of melassigenes than was the case with the unmanured beets.

The apparent co-efficient of purity of the juice is also frequently misleading since it takes no account of the nature of the non-sugars present. In beets grown at Bernberg the influence of strong Chili nitre on the maturing of the plant was noticed. Judged by the apparent co-efficient of purity of the juice alone, the beets which had received large quantities of phosphoric acid were the poorest, while those manured with Chili nitre were next, and the unmanured were the best. But no conclusion could be further from the truth than to suppose the beets grown with phosphoric acid were poorer than those which received the nitre. The latter contained three times as much nitrogen in the form of melassigenes as the former. The nitrogen, therefore, should be separated into albuminoid, betain, and ammoniacal groups. The term betain includes all organic bases which are precipitated with phosphotungstic acid. The real purity of the beet is also to be distinguished from the apparent purity of the juice. The real purity of the beet is obtained by dividing the percentage of sugar in the beet by the total solid matter therein; the apparent purity of the juice by dividing the percentage of sugar therein by the apparent percentage of solids as indicated by the Brix spindle. Judicious fertilizing with nitrate of soda, however, is beneficial, as will be seen by the statement of Dr. Peterman further on.

EXPERIMENTS WITH BASIC PHOSPHATE SLAG AS A FERTILIZER FOR THE SUGAR BEET.*

"Kuster concludes in the following expression that 'the basic phosphate slag is not adapted for application to heavy soils, and that the easily soluble phosphates are to be preferred in such instances.' Although some doubt may attach to a generalization based upon a limited number of experimental observations, the above conclusion may have a value in comparison with our experiments, notwithstanding that the methods adopted were not the same and the respective fertilizers contained differing quantities of phosphoric acid.

* By Em. v. Proskowetz, jr. Zeitschrift Rübenzucker Industrie, February, 1888, p. 127. Abstract.

"The experiments to be given were carried out at Kwassitz upon a heavy, humous, lowland soil, which had been previously planted with clover and wheat, and receiving a liberal dressing of farm-yard manure before taking the latter crop. The phosphate slag applied contained a total of 20.5 per cent phosphoric acid, of which only 0.04 per cent. was soluble in 'citrate solution.'

"The superphosphate used in comparative experiments contained in total phosphoric acid 17.3 per cent, of which 12.44 per cent was soluble in water.

- I. Three plats received 6 kilograms slag in the fall.
- II. Three plats received 8 kilograms slag in the fall.
- III. Three plats received 8 kilograms slag in the spring.
- IV. Three plats received 4.2 kilograms superphosphate in the spring.

"Yield in beets (roots without leaves) of the several plats.

	Kilograms.
Unmanured	633
I. For 35 kilograms phosphoric acid, yielded.....	714
II. For 47 kilograms phosphoric acid, yielded.....	859
III. For 47 kilograms phosphoric acid, yielded.....	934
IV. For 20.7 kilograms phosphoric acid, yielded.....	1,600

"Percentage of sugar contained in beets grown upon the several plats.

Unmanured.	I.	II.	III.	IV.
Per cent. 14.3	Per cent. 14.3	Per cent. 14.1	Per cent. 14.3	Per cent. 14.4

"In this special instance it appears to be demonstrated that phosphate slag is less operative upon the heavy soils of this locality than the usual applications of superphosphates.

EXPERIMENTS WITH FERTILIZERS UPON SUGAR BEETS.*

"The experiments were conducted during the year 1889, and the results may be summarized as follows:

"(1) In two experiments it was shown that exclusive fertilizing with N-manures was effective and economically practicable.

"(2) In most experiments this year the application of P_2O_5 caused an increased yield. Most observable was the excess of value obtained from the use of the P_2O_5 in the form of superphosphate over the P_2O_5 contained in basic phosphate slag. It has been concluded that $2\frac{1}{2}$ kilograms of P_2O_5 in form of phosphate slag are necessary to substitute 1 kilogram of P_2O_5 of the water soluble phosphate. The operation of the P_2O_5 of the slag phosphate is more moderate and constant than the P_2O_5 of the superphosphate, which latter has an earlier and more powerful effect on the young plant.

* By Em. v. Proskowetz, jr.

"(3) The percentage of optically active non-crystallizable matters has been extremely high this year, and was the highest where N-fertilizers were used and the lowest where the superphosphates were applied.

"(4) The experiments indicate that the basic phosphate slag should be used with reticence and discretion. Further, that the use of nitrogen mixed with superphosphates is in given localities the most safe and economical fertilizer."

The following observations in respect of fertilizing are taken from the report of Commercial Agent Howes:*

"MANURING.

"The sugar-beet, of all the cultivated plants, needs the greatest amount of nourishment in the soil. It is, therefore, very necessary to use such a manure as will supply it with the best nourishment and in such a condition that it can be taken up by the beet. Possibly some soils are rich enough to do without manuring, but this seldom occurs. There are cases where beets have been raised in the same fields for ten successive years without fertilizer, and yet good crops have been obtained.

"The ability of the sugar-beet to disclose and take up nourishment is not very high, and, therefore, if a large crop is desired, much manure must be used. Manure must be used that will increase the percentage of sugar as well as the quantity of the crop.

"According to E. Wolff, in 1,000 kilograms of sugar-beets are—

Constituents.	Roots.	Leaves.
	<i>Kilograms.</i>	<i>Kilograms.</i>
Water.....	815	897
Nitrogen.....	1.6	3
Ashes.....	7.1	15.3
Potassium.....	3.8	7
Sodium.....	.6	2
Lime.....	.4	3.1
Magnesia.....	.6	1.7
Phosphoric acid.....	.9	.7
Sulphuric acid.....	.3	.8
Silicic acid.....	.2	1.6
Chlorine.....	.3	1.3

"If we calculate per hectare (2.5 acres) 30,000 kilograms of beets (67,500 pounds) and 7,000 kilograms (15,750 pounds) of leaves, there is removed from the ground by beets—

Description.	Nitrogen.	Potassium.	Phosphates.
	<i>Kilograms.</i>	<i>Kilograms.</i>	<i>Kilograms.</i>
Roots.....	48	114	27
Leaves.....	21	28	5
Total.....	69	142	32

* Sugar-beet industry of Bohemia.

"STABLE MANURE.

"The direct application of stable manure to the beet is not good, because the beet will then not ripen at the right time, and the quality will be poor. Stable manure should not be put in the soil in the spring. It should be plowed under in the fall. The manure of sheep is worthless, as it contains too much nitrogen and potassium, and the amount of salts in the beets is so increased that they are hardly fit for the factory. Manure of cattle can be used if mixed with that of horses. This manure contains sufficient nourishment, but the amount of nitrogen in proportion to phosphoric acid is too high. This should be 1 to 2, but in this manure it is just the contrary. The amount of manure usually needed per hectare (2.5 acres) is between 20,000 and 40,000 kilograms. According to a table by Wolff there is produced in the ground by applying 30,000 kilograms of manure, 150 kilograms nitrogen, 78 kilograms phosphates, and 189 kilograms potassium. From this nourishment the result of applying freshly decomposed manure is, in the first year, 35 to 50 per cent; in the second year, 40 to 35 per cent; in the third year, 25 to 15 per cent. An average crop of sugar beets (30,000 kilograms) needs 69 kilograms nitrogen, 32 kilograms phosphates, and 142 kilograms potassium. Compost is a very good manure, but it is not good to use any sugar-beet soil in its preparation, as it may contain nematids.

"FERTILIZERS.

"In applying fertilizer not only the crop but the quality of the beets will be better if it be used alone or employed to modify stable manure. Generally nitrogen, salts, and phosphates are used; exceptionally, potassium. According to P. Wagner the following amount of phosphoric acid and nitrogen should be used.

Description.	Minimum per hectare.	Mean per hectare.	Maximum per hectare.
	<i>Kilograms.</i>	<i>Kilograms.</i>	<i>Kilograms.</i>
Dissolved phosphates	40	60	80
Nitrogen	20	30	60

"If nitrogen, as Chili nitrate, is used, then there will be needed 150 kilograms minimum, 250 kilograms mean, and 400 kilograms maximum.

"TIME FOR MANURING.

"Manuring should always be done as early as possible in the fall. The longer the manure has been in the ground before the vegetation of the beet the greater will be the amount of nourishment and its distribution. Experiments show that manuring in spring is wrong, and there are many reasons why. For instance, if the season is dry the manure can not decompose, the ground remains loose, and consequently

the young plant suffers for water. On the other hand, as soon as a heavy rain comes after a drought the leaves grow very fast, but the plant does not ripen well, and a large crop is raised, but of a poor quality. If the manure is not decomposed the work in the field can not be done in good shape, and insects have a good refuge. On heavy, loamy soils fresh manure is good for loosening it and allowing the air to enter.

"How deep to put the manure.—It is best first to put the manure in the ground as shallowly as possible, because it decomposes better until the deep plowing is done. The more nitrogen the beet finds in the first period of its vegetation the better. The less nitrogen found in the ground in the first period the more will be taken up in the last period, and that means a loss for saccharification.

"The following table shows, by the experiments of Liebscher, that the crop may be increased without losing in quality, if the manure be properly applied and the beets planted closely :

Manure per hectare.	Sap.		Crop per hectare.
	Sugar.	Quotient in purity.	
	Per cent.	Per cent.	Kilos.
None	16.4	89.1	31,065
20,000 kilograms	16.3	87.4	34,785
30,000 kilograms	16.4	88.8	35,435
40,000 kilograms	16.2	89.1	42,100

"The more nitrogen there is in the soil the less fertilizer will be required, but the more phosphate.

"The increase of the crop by fertilizing with nitrogen is, according to experiments by Wagner : 100 kilograms Chili saltpeter with $15\frac{1}{2}$ to 16 kilograms of nitrogen increase the crop about 4,500 kilograms of beets and 900 kilograms of leaves. Fertilizing with nitrogen should take place only when enough phosphate, lime, and potassium is in the soil, because large and good crops can only be expected when these substances are present. Whether enough phosphate is present can only be learned by experiment. Fertilizing with nitrogen should only be done in the spring. Chili nitrate should always be preferred, and the following rules should be observed :

"(1) A good variety must be planted.

"(2) Seeds should be obtained from the best sources.

"(3) In addition to Chili nitrate, phosphate must be added, or the crop will mature too late.

"(4) Fertilizing with Chili nitrate should be done before sowing, not after.

"(5) Beets must be thickly planted, and cultivated four or five times.

"According to the calculations of Stutzer, the use of more than 400 kilograms to the hectare of Chili nitrate does not pay.

“Professor Mærker has experimented upon the influence of phosphates with the following results:

“Phosphates do not always produce an effect. If the soil is super-saturated with it, it can cause loss. This has often been observed by practical farmers. The cause is that P_2O_5 quickens maturity or causes an early death of the leaves, and that may lessen the crop, especially in a dry, rainless season.

“Ten experiments have given the following results:

Fertilizer.	Crop per hectare.	Increase.
	<i>Kilograms.</i>	<i>Kilograms.</i>
Without phosphate (P_2O_5).....	32,063	.....
400 kilograms precipitate.....	34,456	2,393
Superphosphate (P_2O_5 —76 to 80 kilograms).....	35,346	3,283
400 kilograms Thomas slag.....	33,589	1,526
1,000 kilograms Thomas slag.....	34,756	2,693

“There is not much difference in the effect of the various phosphate fertilizers so far as sugar in the beet is concerned. If it be necessary to use phosphate fertilizers in spring, superphosphate is always to be preferred.

“SPREADING THE FERTILIZER.

“Spreading broadcast has been found to be better than drilling. This is done by the machine shown in Plate 1.

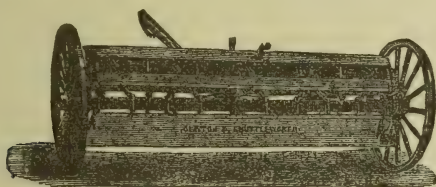


FIG. 26.

“There are, however, drills which have an attachment for drilling fertilizer, as is shown in Plate 2.

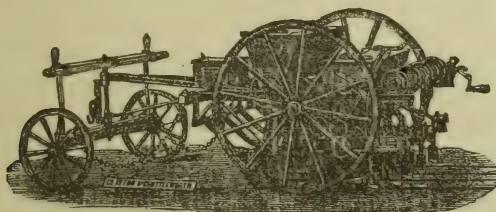


FIG. 37.

“It is very important to put the fertilizer in the right depth. Practical experiments have shown that it should not be used after sowing. In using Chili nitrate, a shallow harrowing is sufficient, because the

next rain will carry it deeper. Potassium and phosphate, which are absorbed immediately, must be put deeper. This can be done with a sharp harrow, or, better still, by shallow plowing. It is said that a depth of 20 to 22 centimeters is the best.

“The following table shows the results of different depths in sandy loam soil per hectare :

Year.	Depth.		Difference.	
	10 to 12 centimeters.	20 to 22 centimeters.		
	<i>Kilograms.</i>	<i>Kilograms.</i>	<i>Kilograms.</i>	<i>Per cent.</i>
1881.....	32, 674	38, 543	5, 869	17. 96
1882.....	36, 217	39, 030	2, 813	7. 77
1883.....	65, 726	69, 596	3, 870	5. 89

“MIXED FERTILIZER (PHOSPHATE AND NITROGEN).

“Of these are used : Peruvian guano (7 per cent nitrogen to 10 per cent $P_2 O_5$) ammonia superphosphate; blood manure with superphosphate. Bone-dust is seldom used, as its effect is too slow; if used, it must be applied in the fall.

“Although most soils have potassium enough, it may occur that lands where beets are raised every year may need it. The direct application of potassium salts to the beets is not good, because all these salts contain a chloride which injures the plants. The best is to give potassium mixed with stable manure two years before the beets are planted. When thus mixed, the ammonia is kept from becoming volatile.

“*Lime.*—Quicklime is a good fertilizer, especially on very heavy soils, which it loosens. For 1 hectare 24 to 40 kilograms should be used.

“For sandy soils marl is excellent, the best containing 30 to 50 per cent of lime. The amount of marl needed for 1 hectare, if containing 30 per cent of lime, is 220 kilograms; if containing 50 per cent, only 130 kilograms.”

In general it may be said of fertilizers that they must be judiciously applied if a maximum benefit is to be secured. Especially is this true of nitrogenous fertilizers, which, when applied to soils already rich in nitrogen, or in excessive quantities or at inopportune seasons, may, by delaying the maturation of the crop and decreasing the relative percentage of sugar, prove injurious. Nitrogenous manures should be applied to the soil and thoroughly incorporated therewith before seeding, and should in general be supplemented with phosphate and potash fertilizers. The quantity of nitrogen may vary from 15 to 30 pounds per acre. A fertilizer containing about 14 per cent. of nitrogen should therefore be used in quantities of from 125 to 250 pounds per acre.

STUDIES ON THE DEVELOPMENT OF THE SUGAR-BEET.*

In a most valuable brochure of 87 pages, with six figures and ten heliograph plates,† Girard has traced the development of the beet from the beginning of its growth to complete maturity. In its various stages the proportional weight of roots, stems, and leaves has been established and the development of sugar traced. In Plate 1 complete plant at maturity is shown.

This weight of the entire plant was found to be 1,527 grams.

This weight was divided as follows:

Leaves :	
Stems	grams.. 161
Leaf	do.... 376
Body (containing 12.19 per cent sugar)	do.... 965
Top, root, and radicles	do.... 25
	1,527
Extreme length of root	meters.. 2.5
Surface :	
Foliage	sq. centimeters.. 3,520
Body	do.... 417
Radicles	do.... 2,920

GENERAL CONCLUSIONS.

Girard, as a result of his studies, calls attention to the origin of the sugar which the body of the beet has stored up and the fact that its development has been followed step by step.

To comprehend well the storage of sugar it is necessary to get an exact statement of the absolute and relative growth of the three principal parts of the beet, viz, body, foliage, and radicles. These proportions at various periods of growth are shown by the following table :

	Body.	Foliage.	Radicles.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
June 8.....	6.8	83.1	10.1
June 19.....	15.1	80.1	4.8
July 2.....	24.8	72.8	2.4
July 15.....	29.5	68.5	2.0
July 29.....	38.9	59.3	1.8
August 10.....	45.7	52.8	1.5
August 24.....	52.0	46.2	1.8
September 5.....	57.3	41.2	1.5
September 18.....	59.8	38.7	1.5
October 1.....	63.3	35.2	1.5

The preceding numbers permit the general character of the plant to be recognized at once during the various periods of its growth. During the first two months the organs pertaining to the foliage are predominant and the activity of the plant is principally directed towards

* By Prof. Aime Girard. Abstract.

† Published by Gauthier-Villars, 55 Quai des Grands-Augustin, Paris.

the production of these parts. The importance of the body during this time is of little moment. In respect of the rootlets, their relative importance is pronounced at the beginning of growth, but rapidly diminishes and soon less than 2 per cent of the weight of the plant represents the radicles. During the last two months of the season vegetation goes on under entirely different conditions.

The foliage and rootlets increase, it is true, but in such feeble proportions as to often seem stationary. The body on the contrary increases rapidly in weight, and at the end of the season it represents about two-thirds of the entire weight of the plant. For each of the parts of the plant in normal conditions of soil humidity this increase is regularly proportioned to the time of growth, and would be represented graphically by almost straight lines, and this is true of body, rootlets, and also for the foliage, provided the normal weight of the withered leaves is taken into account.

Unequal in point of view of intensity for each of the parts, feeble for the foliage and roots, considerable on the other hand for the body, this increase preserves its regularity in respect of the components of all the parts, viz: Cellulose, mineral matters, organic soluble matters, that is to say, matters in course of elaboration. In such a manner is this growth carried on that by leaving out of account intermediate products, it may be said that all the parts of the plant maintain a sensibly constant composition during the most important period of growth, viz, from the month of July on. There are, however, some exceptions to this rule, and although they are not numerous, they are of great importance both from a vegetative point of view and from industrial considerations. Thus the analysis of the roots and rootlets shows them increasing rapidly in vascular tissue and acquiring, by reason of the increase in cellulose, a daily increasing solidity. In like manner the study of the foliage, and notably of the leaf, discloses the presence of sucrose, varying in a relatively important manner under the influence of the light, while on the other hand the products comprising the other vegetative tissues vary in a manner much more restrained.

Also, finally, the study of the body at different epochs of vegetation shows an increasing saccharine richness, intimately connected with meteorological conditions, and notably with the measure of rain which the plant has received. In a word, it is shown that the body increases regularly in weight, whatever be those conditions, but being charged either with water or sugar according to circumstances, and preserving in all cases the sugar which previous vegetative activity has stored up.

From the considerations which precede, it seems possible to define the conditions under which the sugar-beet is developed, the conditions under which the important quantity of sugar is formed which the body has stored away.

From the first months of its vegetation the sugar-beet asserts its coming character, for even when its weight does not exceed 1.5 grams

it contains already 1.5 per cent sugar. Its chief activity at that time, however, is to perfect its foliage and rootlets. But soon, from about the middle of July, its vegetation takes on a different character. Each day, under the direct influence of the sunlight, the leaves form a new quantity of sugar. Each day along the petioles a quantity of sugar, which may be roughly estimated at 1 gram, passes to the body. In the same time there is taken from the soil in aqueous solution a quantity of mineral matter which may be estimated at .15 to .20 gram, and this matter is directed through the body toward the leaves.

The essential part of the plant, that body which at the end of the season represents two-thirds of the whole weight of the plant, ought therefore, no longer to be considered only as a vegetable plexus which, during the first year of the life of the beet, increases regularly with the time, and of which the cellulo-vascular tissue of a composition, sensibly constant during the entire period of vegetation, is filled regularly with water and sugar, the one replacing the other according to meteorological circumstances, and forming in all cases a sum which represents about 94 per cent of the weight of the beet.

CONTRIBUTION TO THE CHEMISTRY AND PHYSIOLOGY OF THE SUGAR-BEET.*

“(1) The application of the chemical fertilizer composed of nitrate of soda, chloride of potash, and superphosphate of lime in quantities which replace the fertilizing principles removed by the last crop is capable of retarding the germination of the seed, in some cases, for as much as three days, according to the degree of humidity in the soil. Two causes contribute to produce this phenomenon; on the one hand the free phosphoric acid and alkaline salts act as antiseptics on the ferments which cause the germination, and on the other hand the chemical fertilizer being very hygroscopic, takes from the seed a portion of the moisture necessary to soften the outside of the seed.

“(2) The morphological development of the sugar-beet is modified under the influence of its environments, that is to say, under influence of different nutriments.

“(3) Maturation of the sugar-beet, which is indicated by the disappearance of the chlorophyll in the leaves, is retarded by the application of nitrogen in the form of nitrate of soda.

“(4) In spite of the production in the same soil of eleven successive crops of sugar-beets the nematoid has never been discovered.

“(5) The quantity of water which traverses a cubic meter of the earth depends on the one part upon the rain-fall, and upon the other on the vigor of vegetation, being directly as the first cause, and inversely the second.

* By A. Petermann. Bulletin of the Association of French Sugar Chemists, December, 1889, p. 253. Abstract.

“(6) Drainage water is more rich in nitrogen where nitrate of soda has been used than where other mineral salts have been employed.

“(7) In a clayey, sandy soil, the regular restitution of the mineral matter alone and of the nitrogen alone, and of the mineral matter associated with the nitrogen, removed by the preceding crop has increased for the ten years of experiment, the production of organic substances respectively from 27 to 50 and 93 per cent, compared with the production obtained without restitution of the nutritive elements. The natural sources of nitrogen are insufficient to show the maximum utilization of the mineral matters restored alone; and, moreover, the decomposition of the soil does not render assimilable sufficient quantity of the mineral matters to permit the sugar-beets to produce, with the aid of restored nitrogen alone, the maximum of organic matter.

“(8) The great oscillations observed in the weight of organic matter produced from year to year, can be caused only by those factors of the experiment which are changeable, namely, meteorological conditions.

“(9) In the experiments made, the production of organic substances the minimum of heat necessary to normal development being furnished, is shown to depend rather upon the height of the rain-fall than with the degree of heat.

“(10) All the conditions being equal and the minimum of the heat necessary to the normal vegetation being furnished, the quantity of sugar contained in the beet at the moment of harvest is in direct proportion to the intensity of light which has prevailed during the whole duration of vegetation.

“(11) In our assays, the centesimal composition of the ash has varied essentially with the environment and has been modified from year to year.

“(12) The quantity of certain mineral elements, phosphoric acid, lime, and magnesia found for a given year are almost in the same proportions in the beets where they are not fertilized as in the others. It is therefore shown that this vegetable absorbs for a given weight of organic substance produced these mineral elements in a certain proportion more or less fixed according to whatever be the proportion of the quantity placed at its disposal.

“(13) The absorption of mineral matters has taken place in the case of lime and magnesia, in the state of phosphate and carbonate, and in the case of potash and soda in a state of chloride, sulphate, and nitrate.

“(14) The quantity of water contained in the beet is a characteristic of the variety; certain variations are noticed from climatic conditions, etc., but in general, the character of the food furnished the plant is without influence upon its richness in water.

“(15) Albuminoids and fats vary greatly in the beets and the extract matters also, while the content of sugar and of cellulose is more constant.

“(16) Of the total nitrogenous bodies contained in the beet at ma-

turity, 58 per cent belong to pure albumens, and 42 per cent to the albuminoids such as the amides and albuminoid glucosides.

“(17) The application of nitrate of soda has exerted a slight depression on the formation of sugar. The diminution of the percentage of sugar due to the nitrogen is more than compensated by the energetic action of this fertilizing principle on the production of total organic substance, and it may be definitely stated that in spite of the decrease in percentage, the total weight of sugar is increased. The total sum of the carbohydrates has been almost the same in all the ten experiments irrespective of the food furnished the plant and has varied chiefly by reason of the intensity of the light.

“(18) The cellulose also has shown little variation.”

TYPICAL FORMS OF SUGAR-BEETS.

The shape of the sugar-beet has much to do with its value as a sugar-producing plant. A smooth and symmetrical exterior permits the beet to be easily harvested and washed. An irregularly shaped beet may easily carry into the cutters sand and earth, and even stones of considerable size, quickly dulling and even breaking the knives of the slicing machine. In selecting mothers, therefore, only beets of smooth and symmetrical exteriors are chosen.

There is thus a tendency to establish a typical form, which varies with the variety of beet. These typical forms for the most approved varieties of beets have been carefully studied and photographed by Professors Eckenbrecher and Maercker, and a few of the most important of these types are reproduced here. In addition to the beets of normal types, there are noticed a few instances of reversion to older and less desirable forms.

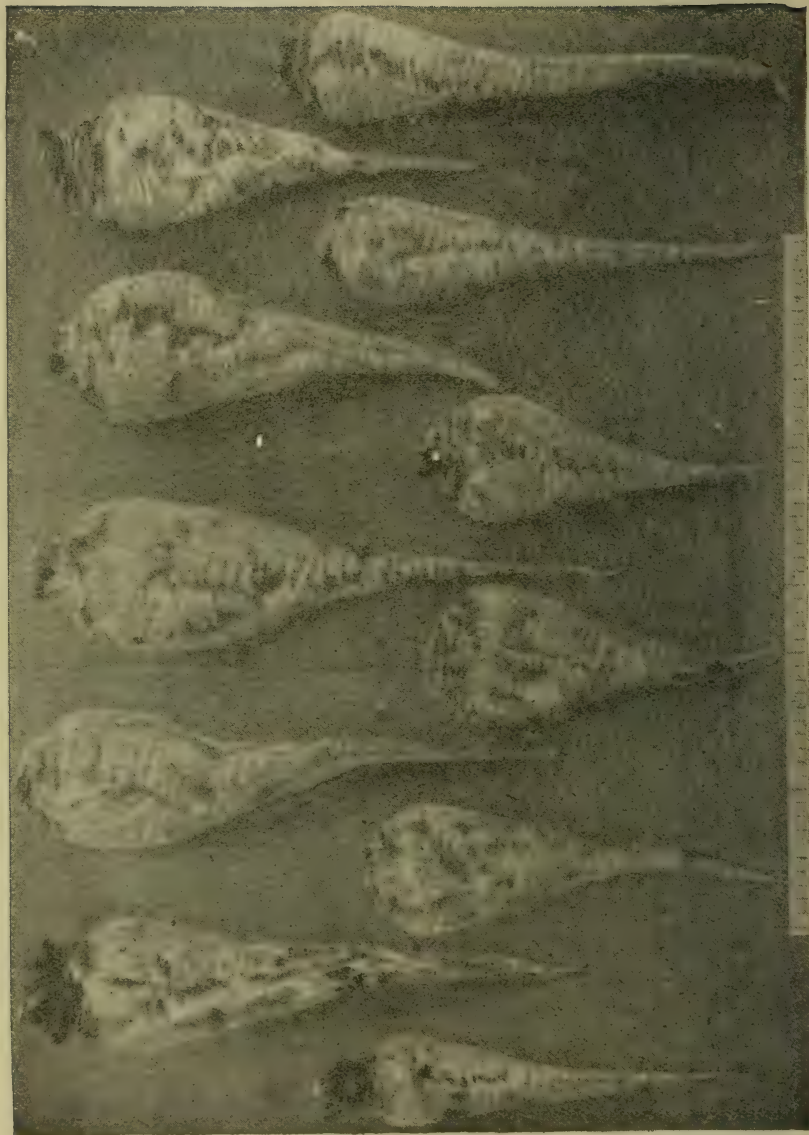


FIG. 38.—Typical Forms of Sugar Beets—Variety, Improved Klein-Wanzleben. Schlitte & Co., Annaburg.

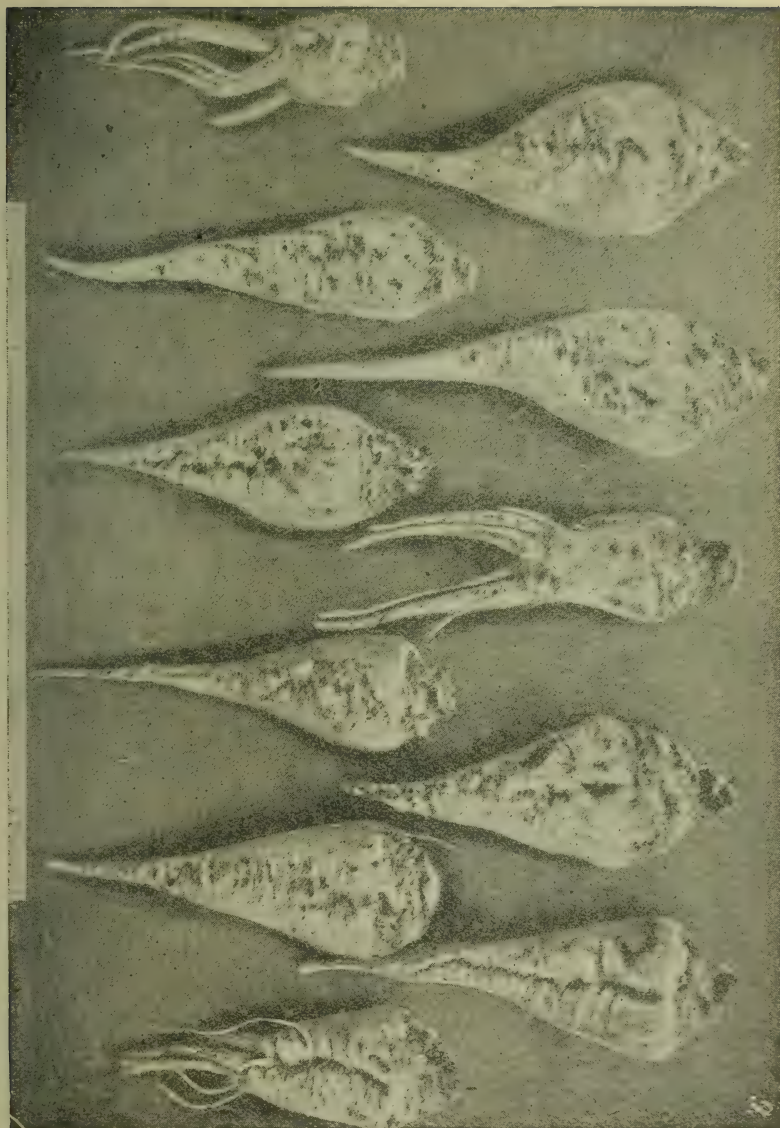


Fig. 39.—Typical Forms of Sugar Beets.—Variety, Vilmorin. Korb-sdorf Sugar Factory.

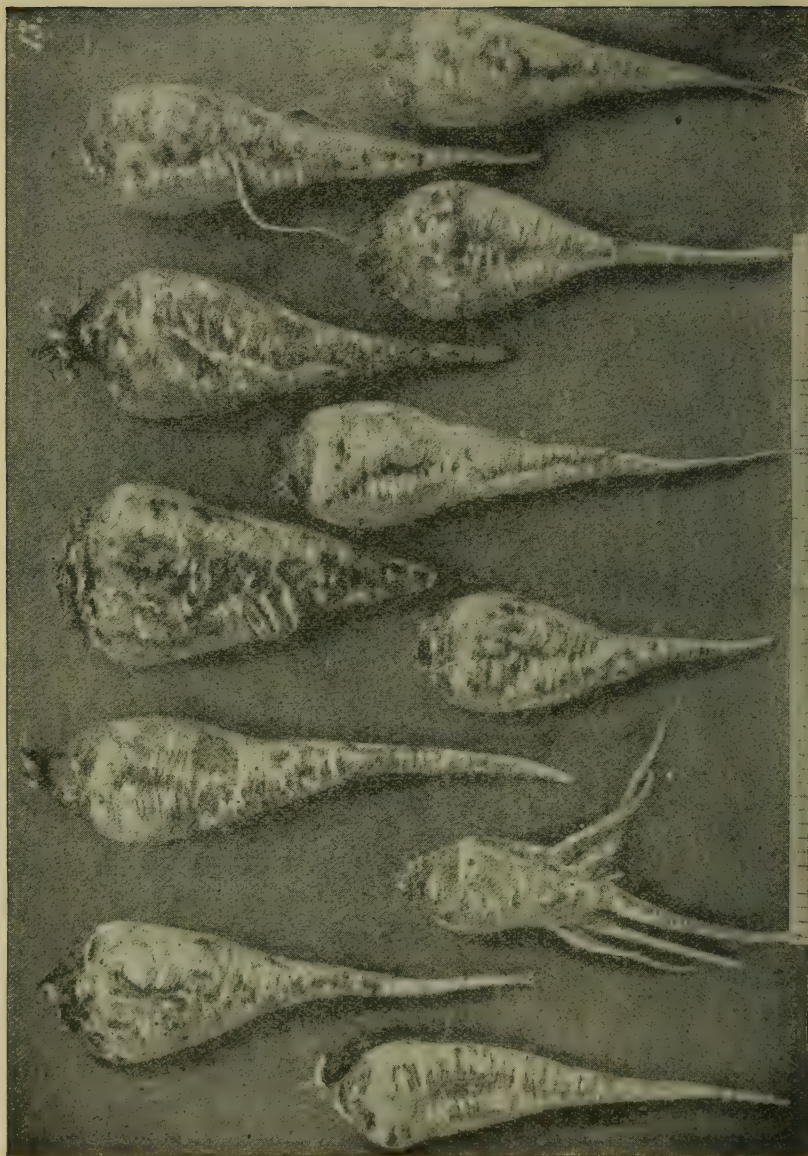


FIG. 40.—Typical Forms of Sugar Beets—Excelsior White, G. Bestehorn.



FIG. 41.—Typical Forms of Sugar Beets—White Improved Imperial White Rose Heart. Martin Grosshoff, Quectinburg.

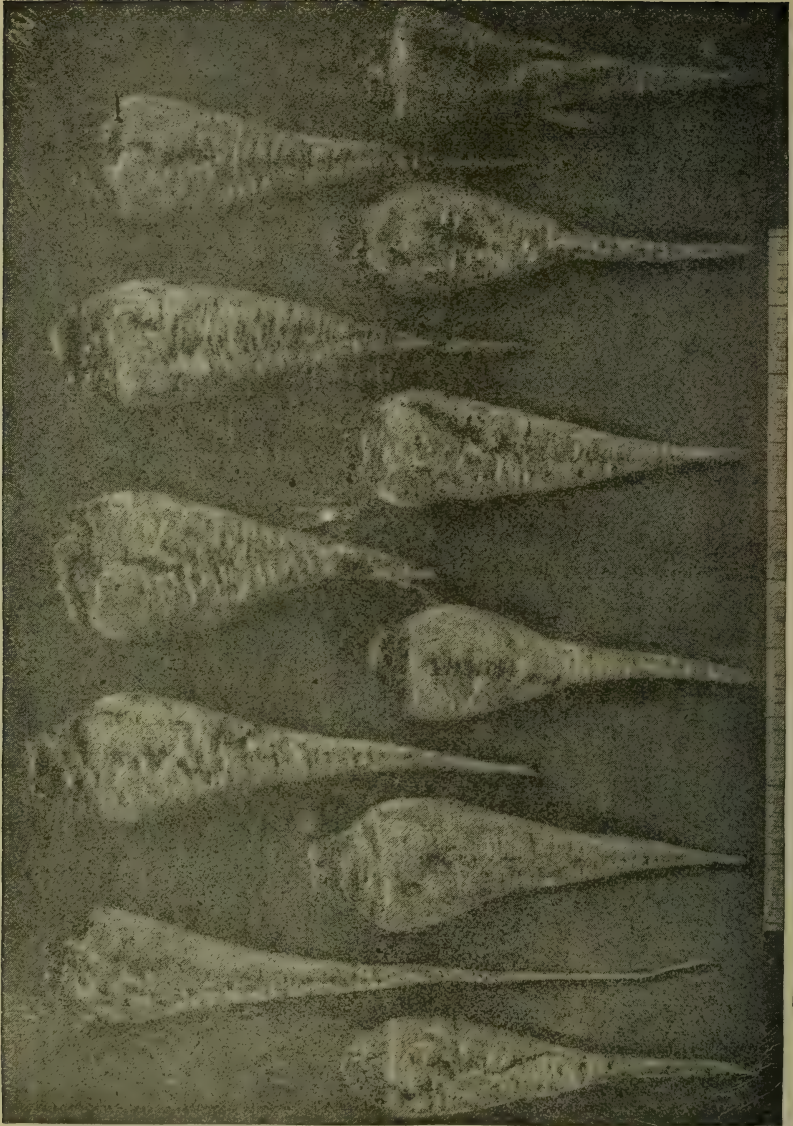


FIG. 42.—Typical Forms of Sugar Beets—Improved White Klein—Wanzleben. Dippe Bros., Quedlinburg.



Map showing Zone 100 miles wide on each side of the mean isotherm of 70° F. for the three Summer Months of June, July and August, for a period of ten years from 1879 to 1890.



METEOROLOGICAL CONDITIONS.

In addition to suitable soil fertilizing and cultivation the sugar beet requires certain meteorological conditions for the highest production of sugar. Temperature and rain-fall exercise the most pronounced influence, not only on the yield of beets but also on their saccharine qualities.

A mean summer temperature of 70° Fah. for ninety days is sufficient to push the beet well on to maturity, while a much higher degree than this tends to diminish its saccharine strength.

The experience of beet-growers in California indicates that in certain latitudes the beet can flourish with a much less rain-fall than has hitherto been deemed a minimum for its proper growth; but this is not conclusive evidence that in all localities so small a supply of moisture would be sufficient. In regions of dry and hot winds or where the sub-soil was less porous, or aerial evaporation much more vigorous, less favorable results would be obtained. Dr. McMurtrie traced his area of beet-sugar limits with an isotherm of 70° Fah. for the summer months, and a minimum rain-fall of 2 inches per month for the same period. By the kindness of the Signal Office I have obtained a record of mean temperatures and precipitation for each month in the year for a period of ten years of those portions of the country in which the culture of the sugar-beet is most likely to succeed. Also from the same source a tracing of the mean isotherm of 70° Fah. for ten years for the three months of June, July, and August. Extending for 100 miles on either side of this line, the map shows a belt extending from the Atlantic to the Pacific, within whose limits the most favorable conditions for growing beets, as far as temperature alone is concerned, will be found.

The mistake must not be made of supposing that all the region included within the boundaries of this zone is suitable for beet-culture. Rivers, hills, and mountains occupy a large portion of it, and much of the rest would be excluded for various reasons. In the western portion, perhaps all but a small portion of it would be excluded by mountains and drouth. Beginning at a point midway between the one hundredth and one hundred and first meridian, as indicated by the dotted line, beets could be grown only in exceptional places without irrigation. On the Pacific coast, only that portion of the zone lying near the ocean will be found suitable for beet culture.

On the other hand, there are many localities lying outside the indicated belt, both north and south, where doubtless the sugar beet will be found to thrive. The map, therefore, must be taken to indicate only in a general way those localities at or near which we should expect success to attend the growth of sugar beets in the most favorable conditions other than temperature alone.

In respect of the rain-fall it is necessary to call attention to the fact that a wet September and October are more likely to injure a crop of

sugar beets than a moderately dry July or August. A wet autumn succeeding a dry summer is almost certain to materially injure the saccharine qualities of the beet before it can be properly harvested. In this regard it will be seen from the tables of precipitation that the two Dakotas are more favorably situated than Oregon and Washington.

The rain-fall in Oregon and Washington for September and October is 2.17, 3.25, and 2.24, and 4 inches, respectively, while in the two Dakotas it is only 1.11, 1.27, and 1.54 and 1.26 inches. The importance of this slight rain-fall in securing a safe harvest without danger of second growth is easily recognized.

During the winter months the temperature that is best for beets is one of uniformity and sufficiently low to prevent sprouting or heating in the silo. Sudden and extreme variations are alike injurious—on the one hand causing danger from freezing and on the other from sprouting. On the coast of California the winters are so mild that the beets require very little protection, in fact more from the heat than the cold, while in Nebraska and the Dakotas the temperature often falls so low as to endanger the beets even in well-walled silos.

All these problems in meteorology deserve the most careful consideration from those proposing to engage in the sugar-beet industry, and it is hoped that the subjoined tables and map may help to elucidate them.

*Table showing the average precipitation, for each month of the year, at the stations specified.
(Deduced from observations during the period January, 1880, to December, 1889.)*

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>
Cornish.....	4.24	4.47	3.24	2.65	3.36	2.94	4.54	3.19	3.76	3.88	4.43	3.93
Eastport.....	4.64	4.49	4.68	3.14	4.82	3.72	4.49	2.82	3.16	4.89	4.22	5.26
Gardiner.....	5.02	5.20	4.27	3.31	3.53	3.09	3.47	2.48	3.62	3.80	3.86	4.64
Orono.....	4.52	4.64	4.06	2.76	3.60	3.29	3.70	3.33	3.38	3.76	4.44	4.45
Portland.....	4.22	4.72	3.23	2.90	3.42	3.04	3.96	3.23	3.51	4.02	4.21	4.44
	4.53	4.70	3.90	3.15	3.75	3.22	4.03	3.01	3.49	3.87	4.23	4.54
New Hampshire:												
Antrim.....	*4.61	*4.27	*3.72	2.80	3.95	3.37	4.53	3.43	4.32	4.00	4.30	4.11
Concord.....	3.83	3.55	2.79	2.14	2.88	3.03	3.67	2.98	3.74	3.16	3.12	3.41
Hanover.....	†2.84	†2.55	†1.84	†1.30	†2.70	†2.90	†3.38	†2.87	†2.49	†2.48	†3.27	†2.47
Weir's Bridge.....	3.84	3.73	2.89	2.32	3.14	3.18	4.01	3.17	3.94	3.40	3.68	3.90
	3.78	3.52	2.81	2.14	3.17	3.12	3.90	3.11	3.62	3.26	3.59	3.47
Vermont:												
Burlington.....	1.68	1.48	1.78	1.67	2.86	2.98	2.82	3.08	3.64	3.12	2.88	1.85
Lunenburg.....	2.99	2.49	2.33	1.15	3.14	3.35	3.60	3.25	3.41	3.76	3.10	2.82
Strafford.....	3.64	3.16	3.14	1.90	3.06	2.95	4.52	3.61	3.70	3.02	3.92	3.28
Woodstock.....	*3.00	*2.77	*2.68	\$1.66	\$3.16	\$2.24	*3.98	*3.00	||3.41	*2.68	*2.09	*3.27
	2.83	2.48	2.48	1.60	3.06	2.88	3.73	3.24	3.54	3.14	3.00	2.80
Massachusetts:												
Amherst.....	4.23	3.72	3.62	2.53	3.59	3.45	4.69	4.08	4.50	3.40	3.77	3.67
Boston.....	4.81	3.99	3.64	2.73	3.86	2.81	3.51	3.58	3.30	3.62	3.38	3.27
Fitchburgh.....	4.61	3.56	2.66	2.56	3.14	2.79	4.05	3.85	3.74	3.24	3.31	3.31
Lawrence.....	*5.44	*4.28	*3.91	*2.75	\$3.30	\$2.84	\$4.18	\$4.87	\$3.59	\$3.77	\$4.69	\$3.58
New Bedford.....	4.78	4.76	3.99	3.45	3.61	3.07	4.00	4.08	3.45	3.56	3.97	3.93
Springfield.....	†4.44	†4.36	†3.23	†2.65	†3.48	†3.80	†4.97	†4.09	†3.52	†3.62	†3.72	†3.84
Williamstown.....	‡3.34	‡1.25	‡3.10	‡2.60	‡3.02	‡2.98	‡4.61	‡3.72	‡3.05	‡2.62	‡3.24	‡3.40
Worcester.....	†4.56	†4.42	†3.49	†2.67	†4.13	†3.63	†3.38	†3.33	†3.84	†3.85	†3.96	†4.06
	4.53	4.04	3.46	2.74	3.52	3.17	4.17	3.95	3.62	3.46	3.76	3.63

* For seven days. † For nine days. ‡ For eight days. § For six years. || For five years.

Table showing the average precipitation, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Rhode Island:	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>
Narragansett Pier	*5.84	*4.95	*4.28	†3.27	†2.88	†2.69	†3.89	†3.99	†3.40	†4.46	†4.32	†3.78
Providence	†6.19	†6.30	†4.33	†3.22	†3.67	†2.99	†4.07	†4.06	†3.29	†4.10	†4.11	†4.59
	6.02	5.62	4.30	3.24	3.28	2.84	3.98	4.02	3.34	4.28	4.22	4.18
Connecticut:												
Hartford	5.10	4.39	3.49	2.53	3.37	2.61	5.02	4.01	3.49	3.97	3.88	4.19
Middletown	3.52	4.95	4.27	2.70	3.17	3.30	5.02	3.59	4.17	4.25	4.02	4.38
New Haven	4.44	4.56	4.30	2.64	3.84	3.14	5.37	4.67	4.04	3.97	3.48	3.97
New London	5.25	5.41	4.46	3.36	3.94	3.47	4.04	4.55	3.77	4.72	4.40	3.77
	4.58	4.83	4.13	2.41	3.58	3.13	4.86	4.20	3.87	4.23	3.94	4.08
Northern New York:												
Albany	2.95	2.56	2.72	2.24	3.13	3.58	3.68	3.67	3.28	3.18	3.46	2.94
Oswego	3.18	2.93	2.49	1.99	3.02	3.61	2.60	2.41	2.66	2.92	3.47	3.66
Rochester	2.61	2.35	2.35	2.16	3.61	3.37	2.30	3.10	2.10	2.63	2.53	2.44
	2.91	2.61	2.52	2.13	3.25	3.52	2.86	3.06	2.68	2.91	3.15	3.01
Northwestern Pennsylv-												
ania:												
Erie	3.38	3.79	2.58	2.76	3.46	4.29	2.73	3.29	3.71	4.06	4.46	3.47
Franklin	3.90	3.38	2.52	2.41	3.50	6.12	4.04	3.54	3.27	2.89	2.94	3.25
	3.64	3.58	2.55	2.58	3.48	5.20	3.38	3.42	3.49	2.48	3.70	3.36
Northern Ohio:												
Cleveland	2.44	3.37	2.34	2.20	2.52	4.03	3.47	2.53	3.38	2.56	3.07	2.54
Sandusky	2.14	3.18	2.38	2.34	3.64	4.29	3.08	3.37	2.59	2.51	2.72	2.54
Toledo	2.14	2.55	1.95	1.98	3.78	3.67	3.29	2.44	2.54	2.92	2.74	2.30
Wauseon	2.40	3.17	2.47	2.43	4.58	3.90	3.51	2.65	2.12	3.14	3.26	2.55
	2.28	3.07	2.28	2.24	3.63	3.97	3.34	2.75	2.66	2.78	2.95	2.48
Northern Indiana:												
Logansport	2.14	4.24	2.59	3.04	5.29	5.15	3.71	2.76	3.08	3.03	3.55	3.44
Michigan:												
Adrian	2.25	§3.48	§2.47	2.60	4.44	4.90	3.81	3.24	3.38	3.79	3.44	2.70
Alpena	3.08	2.61	2.27	2.23	3.81	4.21	3.07	3.24	3.57	3.71	3.16	2.90
Escanaba	2.04	1.68	1.59	2.06	3.17	3.84	2.74	3.64	4.16	3.51	2.26	2.44
Grand Haven	2.78	3.21	2.38	2.45	3.21	4.04	3.57	3.23	3.50	3.75	2.75	3.14
Kalamazoo	2.46	2.96	1.87	2.24	4.36	4.96	2.93	2.52	3.06	2.84	2.39	2.93
Lansing	1.96	2.68	2.55	2.24	3.92	4.43	3.17	2.90	3.14	3.21	2.66	1.80
Marquette	3.28	§1.88	1.74	2.68	2.71	3.24	2.74	3.27	4.27	3.00	2.72	2.96
Port Huron	2.34	2.97	2.40	2.00	3.43	3.60	2.62	2.44	2.16	2.76	2.63	2.26
	2.52	2.68	2.16	2.31	3.63	4.15	3.08	3.06	3.40	3.33	2.75	2.64
Northern Illinois:												
Chicago	2.22	3.03	2.19	3.08	3.83	3.53	3.86	3.42	2.88	3.65	2.82	2.42
Riley	2.28	2.66	2.37	2.61	3.25	3.64	3.18	3.44	3.16	3.14	2.00	2.05
Sycamore	†2.12	†2.40	†2.10	†3.70	§4.06	§4.78	§4.68	§3.47	§3.23	§4.21	§2.56	§2.59
	2.21	2.70	2.22	3.13	3.71	3.98	3.91	3.44	3.09	3.67	2.46	2.35
Iowa:												
Cresco	1.47	1.11	1.64	2.27	3.73	§4.53	§5.19	§3.52	§4.26	2.29	1.28	1.50
Davenport	1.55	1.91	2.14	2.38	4.42	4.47	3.85	3.64	3.41	3.75	1.88	1.92
Des Moines	1.31	1.29	1.40	2.94	5.30	5.88	4.02	3.74	3.95	3.66	1.77	1.54
Dubuque	1.83	1.84	2.23	2.73	4.12	4.74	4.66	3.39	4.47	3.22	1.75	2.11
Logan	†1.86	1.26	1.42	3.05	4.49	5.82	5.22	3.93	3.00	2.94	§1.44	†1.32
	1.60	1.48	1.77	2.67	4.41	5.09	4.59	3.64	3.82	3.17	1.62	.68
Wisconsin:												
Embarras	2.96	2.65	2.27	2.92	4.45	5.71	5.15	5.58	5.05	4.17	2.94	3.14
La Crosse	1.31	0.99	1.45	2.10	2.80	3.57	5.00	3.85	4.71	2.15	1.32	1.32
Madison	2.08	2.30	2.54	2.92	3.56	4.64	5.36	3.76	3.71	3.28	1.76	2.55
Milwaukee	1.96	2.36	2.16	2.18	2.78	3.95	3.80	2.68	2.71	2.24	1.60	2.22
	2.08	2.08	2.10	2.53	3.40	4.47	4.83	3.97	4.04	2.98	1.90	2.31

* For seven days. † For nine days. ‡ For eight days. § For nine years. || For eight years.

Table showing the average precipitation, etc.--Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Minnesota:	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>
Duluth	1.26	.34	1.35	2.44	3.50	4.52	3.32	4.14	3.90	3.14	1.76	1.33
Moorhead	*0.82	*0.86	*0.76	*2.18	*2.75	*3.84	*4.37	*2.70	*2.40	*2.25	*0.93	*0.83
St. Paul	1.21	1.00	1.21	2.69	2.58	3.55	3.53	2.99	3.24	1.64	1.22	1.33
	1.10	1.07	1.11	2.44	2.98	3.97	3.74	3.28	3.18	2.31	1.30	1.16
North Dakota:												
Bismarck	0.52	0.61	0.67	1.86	2.11	2.98	2.68	1.98	0.88	1.04	0.52	0.75
Fort Buford	0.66	0.43	0.42	1.11	1.51	3.07	1.96	1.55	0.84	0.80	0.35	0.56
Fort Totten	0.48	0.59	0.38	1.24	2.11	3.84	2.62	2.66	0.80	1.49	1.02	0.75
St. Vincent, Minn.	*0.48	*0.50	*0.53	*1.26	*2.00	*3.01	*2.70	*2.28	1.93	1.76	0.56	0.71
	0.54	0.53	0.50	1.37	1.93	3.22	2.49	2.12	1.11	1.27	0.61	0.69
South Dakota:												
Deadwood, Rapid City ..	1.25	1.34	1.78	3.98	4.19	3.66	2.70	2.31	0.86	1.06	1.24	1.12
Fort Sisseton, Wads- worth	0.39	*0.37	*0.87	*1.78	*2.33	*3.50	*3.16	*3.38	*1.30	*1.81	†0.56	*0.52
Fort Sully	0.51	0.43	0.53	1.84	2.10	3.16	2.67	2.23	0.82	0.52	0.36	0.49
Yankton	0.59	0.77	1.05	3.35	4.83	3.14	3.16	3.30	3.17	1.66	0.84	0.87
	0.68	0.73	1.06	2.74	3.36	3.36	2.92	2.80	1.54	1.26	0.75	0.75
Nebraska:												
De Soto	1.00	0.86	1.55	2.29	3.64	4.71	3.86	3.55	2.56	2.45	0.89	1.10
Genoa	0.93	0.67	1.03	2.85	3.96	4.21	4.57	2.86	3.29	1.58	0.66	0.86
North Platte	0.34	0.38	0.70	2.03	3.30	3.58	2.76	2.72	1.57	1.37	0.37	0.55
Omaha	0.82	0.91	1.53	2.91	4.64	5.76	5.26	3.55	3.06	2.97	0.92	0.94
	0.77	0.70	1.15	2.52	3.88	4.56	4.11	3.17	2.62	2.12	0.71	0.86
California:												
Benicia Barracks	2.87	*2.06	*2.75	2.62	0.70	0.30	Trace	Trace	0.25	†1.33	*2.10	4.60
Fort Bidwell	3.51	2.46	2.03	*2.31	†1.11	†1.13	*0.32	*0.09	*0.27	*1.66	1.90	*3.47
Fort Gaston	9.99	6.45	4.30	5.69	2.60	0.96	0.10	*0.04	*0.88	*3.55	4.76	10.68
Los Angeles	2.39	3.88	3.35	1.92	0.41	0.16	0.04	0.06	0.07	1.07	1.67	4.29
Red Bluff	3.05	2.04	2.80	2.54	1.00	0.65	0.01	0.00	0.63	1.83	3.33	5.44
Sacramento	3.15	2.28	3.17	3.01	0.77	0.25	0.00	0.00	0.03	1.29	2.52	4.96
San Diego	1.91	2.38	2.05	1.19	0.50	0.09	0.01	0.05	0.02	0.63	0.76	2.40
	3.82	3.01	2.92	2.75	1.01	0.51	0.07	0.03	0.31	1.62	2.43	5.12
Oregon:												
Albany	7.92	5.70	3.67	3.51	2.27	1.71	0.60	0.40	1.78	3.76	3.98	8.76
Eola	7.16	4.73	3.27	2.73	1.84	1.39	5.48	5.22	1.84	3.40	3.59	7.06
Fort Klamath	3.62	2.44	*1.42	1.52	1.35	†1.49	5.70	1.14	4.73	†1.68	*1.99	*4.19
Portland	7.28	4.97	3.72	3.66	2.48	1.71	0.61	0.56	1.93	4.31	5.01	9.56
Roseburg	6.06	3.92	2.30	2.87	1.55	1.48	0.51	0.15	*0.58	3.01	3.18	6.78
	6.41	4.35	2.88	2.86	1.90	1.56	2.58	1.49	2.17	3.25	3.55	7.27
Washington:												
Blakeley	6.25	4.32	4.02	2.81	2.05	1.48	0.83	0.80	2.15	3.73	4.22	7.86
Fort Canby	8.08	7.15	5.94	4.63	3.06	2.37	1.26	0.87	3.35	6.26	6.96	9.84
Olympia	8.68	5.78	4.14	3.83	2.50	1.70	0.71	0.56	2.54	4.31	4.97	9.00
Port Townsend	2.71	1.46	1.33	1.73	1.43	1.28	0.98	0.74	0.90	1.93	2.17	3.08
	6.43	4.68	3.86	3.25	2.26	1.71	0.94	0.74	2.24	4.06	4.58	7.47

* For nine years.

† For eight years.

‡ For seven years.

Table showing the mean temperature in degrees F. for each month of the year at the stations specified. (Deduced from observations during the period, January, 1880, to December, 1889, inclusive.

State and station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	°	°	°	°	°	°	°	°	°	°	°	°
Cornish.....	18.1	20.4	27.6	41.4	55.3	65.3	68.6	66.5	58.5	45.7	34.7	24.4
Eastport.....	20.4	21.9	28.1	38.4	47.3	55.8	60.5	60.4	55.8	46.3	37.4	26.5
Gardiner.....	17.9	20.6	26.7	41.0	53.5	*62.0	67.2	65.0	58.3	46.5	36.8	25.6
Orono.....	15.4	18.8	27.0	40.0	52.0	62.5	67.0	65.0	57.3	45.1	35.2	23.6
Portland.....	23.0	25.1	32.0	44.8	54.3	63.9	68.4	72.7	59.9	48.8	39.4	29.2
	19.0	21.4	28.3	41.1	52.5	61.9	66.3	65.9	58.0	46.5	36.7	25.9
New Hampshire:												
Concord.....	21.5	24.5	30.8	45.3	57.2	65.3	69.4	67.1	60.3	49.0	38.7	28.2
Hanover.....	*17.5	18.8	26.6	40.6	56.5	64.1	69.3	65.6	58.2	45.6	33.8	22.4
	19.5	21.6	28.7	43.0	56.8	64.7	69.4	66.4	59.2	47.3	36.2	25.3
Vermont:												
Burlington.....	18.7	20.6	27.5	42.8	58.6	66.6	71.0	69.2	61.6	47.6	37.1	25.6
Lunenburg.....	14.5	16.8	24.0	38.8	55.4	63.3	67.3	65.1	57.9	44.2	33.2	21.5
Strafford.....	15.1	17.6	25.1	41.3	57.1	63.9	69.5	67.5	59.3	46.3	34.8	22.4
Woodstock.....	12.8	18.1	25.3	40.4	55.7	64.7	68.8	65.3	58.2	45.1	32.6	21.3
	15.3	18.3	25.5	40.8	56.7	64.6	69.2	66.8	59.2	45.8	34.4	22.7
Massachusetts:												
Amherst.....	23.3	25.0	32.1	46.2	57.9	66.6	70.7	68.0	61.4	49.0	39.5	29.6
Boston.....	26.7	28.1	33.3	44.6	55.7	65.9	70.3	68.5	62.2	50.8	41.8	32.2
Pitchburg.....	21.9	23.6	29.0	42.8	56.4	65.8	69.7	66.8	60.2	47.3	37.1	27.6
Lawrence.....	†22.7	†22.7	†31.0	†45.2	†58.8	†67.2	†72.0	†67.2	†59.8	†48.0	†38.4	†27.6
New Bedford.....	27.5	†28.4	†31.0	†43.9	†54.1	†64.1	†69.2	†67.3	†60.1	†51.0	†42.6	†31.8
Springfield.....	24.0	25.9	32.5	46.8	60.5	68.8	72.8	68.9	63.3	50.4	40.0	*30.0
Williamstown.....	20.2	22.6	28.2	42.7	56.8	64.6	68.2	64.6	58.7	47.0	37.1	26.6
Worcester.....	23.4	23.9	30.0	†42.8	†55.2	*65.1	*70.0	66.8	*60.7	*48.0	38.7	28.6
	23.7	25.0	31.2	44.4	57.0	66.0	70.4	67.3	60.8	48.9	39.4	29.2
Rhode Island:												
Providence.....	†25.3	†28.5	†32.2	†45.4	†56.5	†67.6	†73.1	†69.8	†62.1	†51.2	†41.9	†31.1
Connecticut:												
Hartford.....	†22.4	†24.0	†30.3	†46.7	†59.4	†67.2	†72.2	†68.2	†60.7	†48.6	†39.8	†29.2
Middletown.....	†24.3	†23.9	†31.4	†46.4	†58.7	†65.9	†70.5	†67.2	†55.5	†48.4	†40.4	†31.0
New Haven.....	26.5	28.1	33.5	45.7	57.3	66.3	71.0	69.0	63.3	51.7	41.6	32.0
New London.....	28.9	30.0	35.0	46.0	56.6	65.6	70.5	69.1	63.7	53.0	43.4	34.0
	25.5	26.5	32.6	46.2	58.0	66.2	71.0	68.4	60.8	50.4	41.3	31.6
Northern New York:												
Albany.....	23.4	25.6	32.1	47.1	60.7	69.0	73.1	70.7	63.8	51.1	40.7	30.0
Oswego.....	23.3	24.3	28.8	41.5	54.5	62.6	68.4	67.1	61.3	49.0	39.1	29.4
Rochester.....	23.1	24.0	28.8	42.7	56.6	*62.5	*69.5	*67.4	*62.2	48.7	38.2	29.1
	23.3	24.6	29.9	43.8	57.3	64.7	70.3	68.4	62.4	49.6	39.3	29.5
Northwestern Pennsylvania:												
Erie.....	26.1	27.2	31.3	43.8	57.2	65.8	70.6	68.7	63.2	51.8	40.9	32.5
Franklin.....	21.8	23.9	29.1	43.7	56.0	60.2	65.5	62.5	56.8	45.3	34.2	26.2
	24.0	25.5	30.2	43.8	56.6	63.0	68.0	65.6	60.0	48.6	37.6	29.4
Northern Ohio:												
Cleveland.....	25.3	27.8	32.5	45.1	58.8	66.7	71.1	69.0	63.8	52.1	40.1	31.4
Sandusky.....	25.8	28.4	33.6	45.4	*59.5	*67.0	*72.9	70.7	64.9	52.5	40.5	31.8
Toledo.....	25.2	27.9	34.2	46.8	59.8	68.5	73.2	70.2	64.1	52.1	40.3	31.3
Wauseon.....	21.4	24.9	31.8	46.0	58.5	67.2	71.9	68.9	62.9	49.8	36.9	27.7
	24.4	27.2	33.0	45.6	59.2	67.4	72.3	69.7	63.9	51.6	39.4	30.6
Northern Indiana:												
Logansport.....	*24.0	†29.9	†36.7	*52.9	*64.7	*71.2	*76.2	*73.9	†67.2	†55.3	*40.0	*30.7

* For nine years. † For eight years. ‡ For seven years. § For six years. || For five years.

Table showing the mean temperature in degrees F. for each month, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Michigan:	o	o	o	o	o	c	o	o	o	o	o	o
Adrian	20.3	*25.9	*31.0	45.2	58.4	67.2	71.6	68.4	61.7	49.1	36.6	28.2
Alpena	16.9	16.7	22.9	36.4	49.0	59.0	64.7	63.0	56.7	44.7	33.2	25.0
Escanaba	13.6	20.2	21.2	32.6	45.1	54.4	59.5	57.1	51.2	40.4	28.2	20.1
Grand Haven	23.3	24.2	30.0	43.4	54.7	63.2	68.2	66.3	59.2	49.2	38.0	30.0
Kalamazoo	20.6	23.7	30.3	46.2	57.6	67.1	72.3	69.1	62.4	50.4	36.5	28.1
Lansing	21.1	23.4	30.5	45.8	58.6	68.3	72.7	69.8	62.7	44.8	32.9	22.8
Marquette	14.5	*15.5	21.8	36.6	49.1	57.6	64.2	62.3	56.1	44.5	31.9	23.8
Port Huron	19.2	21.7	28.1	41.5	53.1	63.3	68.3	67.0	60.6	48.8	35.7	26.9
	18.7	21.7	27.0	41.0	52.4	62.5	67.7	65.4	58.8	46.5	34.2	25.6
Northern Illinois:												
Chicago	22.4	26.3	34.1	46.0	56.4	65.4	71.4	70.6	64.2	52.5	39.2	30.2
Riley	14.6	19.5	29.1	45.6	56.1	65.7	70.3	67.9	60.2	47.9	33.3	23.1
Sycamore	115.3	121.0	130.4	146.0	154.5	166.8	171.2	168.6	159.9	148.7	135.5	126.2
	17.4	22.3	31.2	45.9	55.7	66.0	71.0	69.0	61.4	49.7	36.0	26.5
Iowa:												
Cresco	7.4	13.6	26.7	44.4	56.2	*66.2	*70.4	*68.1	*58.6	45.8	29.0	18.3
Davenport	19.4	24.9	35.0	50.1	61.2	69.7	74.8	72.2	64.4	52.2	38.2	28.3
Des Moines	16.6	23.1	34.7	50.2	60.9	69.8	74.5	72.1	63.5	51.7	36.6	26.5
Dubuque	16.1	21.7	32.7	48.6	60.1	68.5	73.6	70.9	63.6	50.4	35.7	25.6
Logan	16.5	22.4	35.2	51.7	63.2	71.6	75.9	74.0	65.9	52.4	36.1	26.1
	15.2	21.1	32.9	49.0	60.3	69.2	74.6	71.5	63.2	50.5	35.1	25.0
Wisconsin:												
Embarrass	11.2	15.5	26.4	44.2	59.1	68.0	71.0	68.2	60.9	48.5	32.4	21.2
La Crosse	13.4	19.1	30.5	47.3	59.8	68.5	72.7	69.8	61.4	49.5	34.3	23.8
Milwaukee	17.9	21.9	30.3	42.4	53.3	61.7	68.4	67.4	60.7	49.7	36.0	26.4
	14.2	18.8	29.1	44.6	57.4	66.1	70.7	68.5	61.0	49.2	34.2	23.8
Minnesota:												
Duluth	7.9	12.4	23.2	37.5	48.1	57.3	65.2	63.6	55.2	44.4	29.5	17.8
Fort Buford	2.9	2.9	20.0	40.2	53.6	64.5	67.6	65.1	55.3	39.0	24.9	11.1
St. Paul	9.1	14.9	27.9	45.3	57.8	66.9	71.3	68.6	60.0	47.2	31.0	19.4
	4.7	10.1	23.7	41.0	53.2	62.9	68.0	65.8	56.8	43.5	28.5	16.1
North Dakota:												
Bismarck	3.2	9.2	23.0	41.4	54.9	65.0	69.1	67.0	56.3	43.7	26.6	13.8
Fort Buford	2.6	9.3	24.0	41.7	53.9	64.2	68.0	66.1	54.8	42.6	25.8	10.8
St. Vincent, Minn.	*7.5	*0.6	*15.3	*36.6	*51.7	*62.3	*65.0	*62.5	52.6	40.0	21.2	6.2
Fort Totten	*4.5	3.8	17.1	37.7	53.8	64.0	67.3	65.7	55.0	41.3	22.5	8.2
	1.6	5.7	19.8	39.4	53.8	63.9	67.4	65.3	54.7	41.9	24.0	9.8
South Dakota:												
Fort Sisseton	0.4	6.0	21.0	*40.9	*55.2	*65.0	*69.0	*65.1	*56.8	*43.0	*25.4	*11.2
Fort Sully	8.8	15.5	29.6	47.5	58.9	68.9	73.9	72.1	61.9	48.2	30.7	19.1
Deadwood	19.4	22.9	31.3	41.3	50.4	61.1	66.0	65.4	55.2	44.5	32.4	26.0
Yankton	12.6	18.2	30.6	47.0	59.3	69.2	73.5	71.3	61.8	49.6	33.0	22.4
	10.3	15.6	28.1	44.2	56.0	66.0	70.6	68.5	58.9	46.3	30.4	19.7
Nebraska:												
De Soto	14.5	21.5	34.0	50.7	61.5	70.5	74.9	72.6	63.5	51.1	34.4	24.4
Geneva	13.5	20.4	32.3	48.6	60.4	70.0	74.6	72.3	62.8	49.8	33.0	23.4
North Platte	18.6	25.1	35.1	48.5	58.1	68.3	73.2	71.1	62.0	49.6	34.5	27.0
Omaha	16.6	23.4	35.1	51.1	62.2	71.4	76.2	74.4	64.8	52.0	37.0	26.7
	15.8	22.6	34.1	49.7	60.6	70.0	74.7	72.6	63.3	50.6	34.7	25.1
California:												
Benicia Barracks	46.6	*49.6	*54.2	56.9	61.4	65.6	65.8	68.4	*66.6	61.7	54.2	50.3
Fort Bidwell	31.4	33.8	41.4	47.9	*55.9	*63.5	71.0	70.7	62.6	51.2	40.4	35.8
Fort Gaston	41.0	43.7	49.8	53.8	59.8	65.0	71.8	69.3	63.7	54.5	46.0	44.2
Los Angeles	53.6	54.4	56.2	59.0	62.2	65.9	69.4	70.6	68.7	63.1	58.7	55.5
Red Bluff	45.5	49.1	55.2	59.8	67.5	75.2	82.1	80.5	*74.7	62.7	*52.7	47.5
Sacramento	45.5	49.4	54.7	58.2	63.4	68.2	71.9	71.8	69.6	61.0	52.4	47.5
San Diego	53.5	54.7	56.1	58.8	61.5	64.4	67.2	69.1	67.2	62.6	53.3	56.3
	45.3	47.8	52.5	56.3	61.7	66.8	71.3	71.5	67.6	59.5	51.1	48.2

* For nine years.

† For eight years.

‡ For seven years.

Table showing the mean temperature in degrees F. for each month, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Oregon:	°	°	°	°	°	°	°	°	°	°	°	°
Albany	38.6	40.9	47.5	51.8	57.9	61.0	66.3	65.4	62.1	*49.0	43.2	41.8
Eola	37.6	39.8	46.8	50.1	55.8	60.3	60.7	64.4	59.1	51.6	43.7	41.5
Fort Klamath	†26.4	†26.8	†34.7	†40.0	†49.7	†56.9	†61.6	†62.1	†51.7	†41.5	†33.2	†30.4
Portland	37.0	40.0	47.6	51.8	58.0	62.1	66.4	65.3	60.6	53.0	44.8	41.6
Roseburg	40.4	41.6	47.5	51.6	57.1	61.4	66.5	65.0	61.4	52.2	44.5	43.2
	36.0	37.8	44.8	49.1	55.7	60.3	64.3	64.4	59.0	49.5	41.9	39.7
Washington:												
Blakeley	38.5	40.3	46.1	50.8	56.0	61.2	63.3	62.7	57.6	51.0	45.1	41.8
Fort Canby	41.0	41.7	46.0	49.0	53.2	56.5	59.0	59.5	57.8	53.0	47.1	44.1
Olympia	37.6	39.0	44.5	48.7	54.5	59.2	62.3	61.9	56.2	50.1	43.8	40.6
Port Townsend	*38.7	*39.3	†46.2	51.3	55.0	60.0	62.0	61.2	†56.4	*53.4	*44.0	*40.9
	39.0	40.1	45.7	50.0	54.7	59.2	61.6	61.3	57.0	51.9	45.0	41.8

*For nine years.

†For eight years.

‡For six years.

§For seven years.

Dr. McMurtrie, in special report No. 28, has made a careful study of the climatic conditions in the United States favorable to the production of the sugar beet. Maps are given showing the southern limit of a mean temperature of 70° Fah. for the three summer months, coupled with a minimum mean rain-fall of two inches per month for the same period. The tables of temperature and rain-fall, from which these lines were computed, are also given in detail. The observations made on the data collated are as follows:

"We see from this that the sections of the United States most favorable to beet-root culture are confined to the north, including New England, New York, a narrow band south of the lakes, Michigan, parts of Wisconsin, Minnesota, and Dakota. Here the line of the southern limit passes into the British possessions and enters the United States again in Washington Territory, and, crossing Western Oregon, passes to the coast to the extreme north of California. In most of this band we find a favorable temperature, and the average rain-fall is sufficient in quantity, but we are unable to make any observations concerning the number of rainy days. In California, as the tables will show, the temperature is sufficiently moderate, but, from examination of the figures for the stations for which the rain-fall has been recorded, we find it to be remarkably deficient. Here, in order to make the culture a success, it would appear that the intervention of irrigation during the summer months would be an absolute necessity.

"We also note a few counties in the southwestern portion of Pennsylvania, and one county in Ohio, without the general band, where suitable meteorological conditions seem to exist. These counties are surrounded by the red line in the more detailed map that has been prepared, showing the county lines near to or over which the line of the limit of favorable meteorological conditions passes. This map is intended for more ready reference for those who may contemplate establishing the culture in the sections in the near neighborhood of the line.

"Now, I do not mean to assert that the band of country I have thus plotted on the map is exclusively that in which the introduction of beet-root culture may be attempted with prospects of success, but it is certain that within this band the chances of success are greater than they are without it, and it also appears that all the unsuccessful attempts that have heretofore been made to establish the industry have been at points without it. It is therefore advisable that farmers or manufacturers who may design entering upon the prosecution of this industry should study with greatest care these influences which operate with so much benefit or injury upon the profit of the crop. It is evident from what precedes that the beet requires a cool or at least a moderate season for suitable progress in development, that it may not reach maturity in advance of the time for working it into sugar, and under the influence of the rains and elevated temperature of the autumn months enter into a second growth, thereby destroying the valuable constituents which renders it so desirable as a sugar-producing crop.

"In this connection it has been suggested that in sections of protracted warm seasons, when the root will develop and attain full maturity in August, and during the summer drought, the crop could be taken up before the appearance of the autumn rains, and by slicing and drying the roots preserve them until the arrival of the proper season. This mode of procedure has in fact been recommended to the agriculturists of the south of France, and has, it has been stated, been the subject of experiment in Algeria. The method has the objection of being a rather precarious one on account of the chances of the crop being caught after a long-continued drought by late heavy summer showers that would prove almost as injurious as the autumn rains.*

"After the directions given by Briem and others it is scarcely necessary to recapitulate here the meteorological conditions which appear to be required by this culture, yet the conclusions arrived at from our study of the subject, in addition, may not appear superfluous. The conditions, then, are in general, comparatively dry and warm spring months during the time for preparation of the soil, planting, and cultivating the crop; moderate temperature, abundant and frequent rains during the summer months, the time for ultimate development of the crop and its valuable constituents; cool dry fall, the time for ripening, harvesting, and storing the crop. If these conditions prevail, the results will be good; otherwise they will be but medium or even bad."

The amount of rain-fall necessary to the proper growth of sugar-beets depends largely on the character of the soil, the mean temperature, and the degree of saturation with aqueous vapor of the prevailing winds. In the coast valleys of California, where the proximity of the sea preserves a low temperature through the summer, and where the porous soil permits the tap root of the beet to descend after moisture and moisture to

* The experiment of drying beets for preservation in Maine, in the fall of 1878, proved quite disastrous financially for those who engaged in the enterprise.

ascend to the root, excellent beets are grown with little rain. The conditions would be entirely reversed in inland localities with high summer heats, stiff clayey soils, and arid winds.

In general, the amount of rain-fall during the summer months in the Northern, Central, and Eastern United States is sufficient to secure a good growth, and therefore it may be said that proper soil and locality being provided, beet culture might be undertaken in such localities with little fear of disaster from drought, save in a few exceptional seasons.

In fact, with thorough under drainage and deep subsoil plowing, it would be possible to secure a good crop of beets in the regions indicated quite independently of the variation in the amount of rain-fall.

The chief question, therefore, to be considered, is one of temperature rather than of rain-fall. In the present state of our knowledge it would not be safe to establish beet factories very far south of the mean isotherm of 70° Fahr. for the three summer months, without a more thorough study of the character of the beets produced than has heretofore been made. The possibility of finding localities south of this line, where sugar-beets may be grown with profit, is not denied, but the necessity of further investigation is urgent. There are many places situated only a short distance south of this line where the soil, water supply, cheap fuel, and other local considerations supply peculiarly favorable conditions for beet culture, and in such places the industry would doubtless flourish, although the beet might not be quite as rich in sugar as when grown in a more northern locality. In all cases the length of the growing season should be sufficient for the complete maturity of the beet, and the freezing temperatures of winter should come sufficiently late to allow the beets to be safely harvested and covered. The shaded belt of the map, Plate 2, indicates fairly well those portions of the United States in which areas suited to successful beet culture are most likely to be found.

RECENT EXPERIMENTS LOOKING TO THE INTRODUCTION OF THE BEET-SUGAR INDUSTRY.

EXPERIMENTS IN INDIANA.

Sugar beets have been grown for two seasons at the Agricultural Station at La Fayette, viz, 1888-'89. The experiments for 1889 were conducted as follows:

The seeding took place on the 29th of April in rows 3 feet apart, and the plants were thinned so they stood from 4 to 6 inches apart in the rows. No information is given concerning the method of preparing the land and no note is made of any fertilizers used. The beets were harvested on the 23d and 25th of October. Analyses were made by the chemist of the station, Professor Huston, and a comparison of the yield

per acre and the percentage of sugar found in each variety is found in the following table:

Variety.	1888.		1889.	
	Yield per acre.	Sugar.	Yield per acre.	Sugar.
	<i>Tons.</i>	<i>Per cent.</i>	<i>Tons.</i>	<i>Per cent.</i>
White sugar	14.48	11.35	13.59	13.05
Imperial sugar	14.48	11.67	15.60	12.80
Vilmorin's sugar	12.08	9.92	13.20	12.85
French yellow sugar	12.07	11.64	15.99	9.20
Lane's imperial sugar	8.74	16.40	16.80	10.40

The mean temperature for June, July, and August, 1889, was 69.2° Fah., which is about 3 degrees below the average of this period for ten years.

EXPERIMENTS IN MICHIGAN.

Analyses of sugar beets grown in Michigan in 1889.—There are no details given of the method of planting and cultivating the beets or the time of planting and harvesting. The following data were furnished by Dr. R. C. Kedzie, Chemist of the Agricultural Experiment Station, in a letter under date of October 5, 1889:

No.	Variety.	Sucrose.
		<i>Per cent.</i>
1	Vilmorin Imperial, imported seed	14.58
2	Beets grown on Senator Palmer's farm without manure	11.40
3	Beets grown on Senator Palmer's farm with 200 pounds superphosphates and 200 pounds nitrate of soda per acre	11.40
4	Beets grown on Mr. Klein's farm, Oakland County	12.87
5	Beets grown in Livingston County	7.86
6	Beets grown by George C. Anschuetz, Tawas City, imported seed	12.78
7	Beets grown by George C. Anschuetz, Tawas City, American seed	13.40

EXPERIMENTS IN WISCONSIN.

Under authority of the Secretary of Agriculture I made arrangements with Prof. W. A. Henry, director of the Wisconsin Agricultural Experiment Station, for culture experiments with the sugar beet.

The interesting and instructive report of Professor Henry follows.

The remarkably favorable weather during October is a factor in the production of sugar beets which should not go unnoted. Only a trace of rain fell at Madison in October, and the season for harvesting and siloing could not have been better.

The general results are encouraging, sufficiently so to justify further cultural work, a kind of work which may eventually result in the establishment of factories.

REPORT ON INVESTIGATION OF BEETS FOR SUGAR PRODUCTION IN 1889, AT THE WISCONSIN AGRICULTURAL EXPERIMENT STATION, UNDER DIRECTION OF THE DEPARTMENT OF AGRICULTURE, WASHINGTON.

Varieties and planting.—Three varieties of seed were furnished by the Department, one, not named, being received from the California Beet Sugar Company; the other two, viz, Vilmorin's Improved and Lane's Imperial were received directly from Washington. The seed from California arrived in April, and was planted May 5. The other varieties, for some reason, did not reach Madison until June, and were planted June 6, too late to give entirely satisfactory results as the season after this time was exceptionally dry, causing the beets to grow slowly.

The beets were planted in rows 3 feet apart and were thinned to about 8 inches apart in the rows. They were carefully cultivated, the soil being kept free from weeds, and in good tilth throughout the season.

Meteorology.—The season of 1889 was most remarkable for the very small rain-fall, not one-half the average amount of precipitation being registered for the growing season.

May, June, and October were somewhat cooler than the average, while July and August were slightly warmer.

TABLE I.—Showing temperature and rain-fall.

Rain-fall.			Temperature.			
	1889.	Mean for thirty-three years.	Mean for 1889.	Mean for thirty-three years.	Highest 1889.	Lowest 1889.
	<i>Inches.</i>	<i>Inches.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>
May	3.28	3.6	56.1	57.9	82	34.2
June	2	4.7	63.4	67.2	83.3	42.2
July	2.12	4.31	74.3	72.6	91.6	54.7
August	.72	3.49	70	69.5	90.5	51
September	1.93	3.37	61.18	61.2	90.2	34.8
October	trace.	3.04	46.1	48.8	75.5	29

Development of the sugar in the beet root.—The first analyses were made September 20, and after this date beets from each lot were frequently examined until they were harvested to protect them from the frost on October 22.

The following table gives the per cent. of sugar in the juice from each variety at the dates when examined. The determinations were made with the polariscope.

TABLE II.—Showing per cent. of sugar in juice of beets at different periods.

Vilmorin's Improved.		Lane's Imperial.		California Beet Sugar Company.	
Date.	Per cent.	Date.	Per cent.	Date.	Per cent.
September 20	8.07	September 20	7.97	September 20	8.074
September 22	10.35	October 11	14.40	October 4	9.68
October 9	10.60	October 19	15.60	October 7	10.05
October 14	11.95	.....	.....	October 15	11.54
October 17	15.60	.....	.....	October 22	14.50

Grading the beets.—The beets were harvested October 22, at which time they were divided into two grades, the classification being based upon the shape and manner of growth. The first grade represents those roots that were comparatively smooth and conical in shape. The beets of the second class were irregular in shape, with large, scraggly roots.

This second type of beets was not scattered uniformly through the plot, but grew in patches of three, four, or a dozen together, indicating that some local peculiarity of the soil or treatment was the cause of their irregular development.

Abnormal beets.—A few beets differed in type from the others in growing partly out of the ground. Analyses to determine the sugar from the parts above and below ground are presented in the following table.

TABLE III.—Showing percentage of sugar in different parts of beets.

Part of beet.		Weight.	Sugar in juice.
		Grams.	Per cent.
No. 22 {	Upper half.....	664	9.89
	Lower half.....	449	10.12
No. 23 {	Upper half.....	345	11.81
	Lower half.....	570	11.46

Though the percentage of sugar in the two parts of the beet does not vary much, the percentage for the whole beet is low.

Yield per acre.—At harvesting, the beets and tops were weighed separately. In the following table is shown the weight of the two grades, the tops, and the average weight of each beet-root.

TABLE IV.—Showing yield of beets and weight of tops per acre.

Variety.	No. of beets.	Weight of No. 1 beets.	Weight of No. 2 beets.	Total weight.	Average weight.
		Pounds.	Pounds.	Pounds.	Pounds.
California Beet Sugar Company.....	16,233	13,353	5,938	19,291	1.18
Vilmorin's Improved.....	15,770	12,211	3,384	15,595	.99
Lane's Imperial.....	14,713	11,856	4,501	16,367	1.11

The total yield of beets is much smaller than is usually reported. This is partly due to the season, but chiefly to the distance of the rows apart, it being the custom to plant them only 17 or 18 inches instead of 3 feet, as in this case.

The table shows that from a fourth to a third of all the roots graded as No. 2.

Both types of beets from the California Beet Sugar Company's seed were examined for sugar, two analyses of each being made, with the following results, which show that the No. 1 beets are the richest in sugar :

TABLE V.—Showing per cent. of sugar in No. 1 and No. 2 beets.

	No. 1 beets. Sugar in juice.	No. 2 beets. Sugar in juice.
	<i>Per cent.</i>	<i>Per cent.</i>
No. 1	14.83	14.12
No. 2	14.47	13.50
Average.....	14.54	13.81

Impurities in the juice.—Analyses were made to determine the quality of the juice for the manufacture of sugar. The following table gives the per cent. of sugar, of solids, and the specific gravity of the juice at the dates mentioned.

TABLE VI.—Showing per cent of solids and sugar in the juice.

Variety.	Date of analysis.	Solids in juice.	Sugar in juice.	Specific gravity of juice.
		<i>Per cent.</i>	<i>Per cent.</i>	
Lane's Imperial	Oct. 11	18.43	14.40	1.10
California Beet Sugar Company.....	Oct. 15	17.30	14.53	1.03
Do.....	Nov. 29	15.29	14.12	1.085
Do.....	Dec. 4	15.07	14.83	1.09
Do.....	do	15.22	14.47	1.0825
Do.....	Dec. 5	14.96	13.50	1.08

Quality of the juice in stored beets.—The harvested beets were stored in a barn cellar, the door of which was left open for circulation of air until danger of freezing. The temperature of the cellar ranged from 44° to 41° Fah. by a dry-bulb thermometer, and uniformly 1 degree lower by a wet-bulb thermometer, showing that the air was quite damp. Under these conditions the beets kept well. For the sugar content we may refer to Table VI, where the California beets show 14.53 per cent of sugar in the juice October 15, one week before they were taken from the ground for storage. The analyses for November 29 and the three succeeding dates show the percentage of sugar in the juice of the stored beets.

Conclusion.—Considering the season, the time of planting, and the conditions of culture, the beets certainly showed a very satisfactory sugar content. The weather being quite abnormal, it is but fair to withhold general statements until the work is repeated for at least one season. If this line is continued, an effort will be made to plant and cultivate after the manner of beet fields in sugar districts.

EXPERIMENTS IN IOWA.

Experiments were made at the Agricultural Experiment Station at Ames during 1888 and 1889, and the results of these experiments are published in Bulletin No. 8 of the Station, pages 321 to 326, inclusive.

These experiments were conducted under the direction of Prof. G. E. Patrick.

Four varieties of sugar-beets were grown in 1888 and two in 1889. Those grown in 1888 were from seed purchased from seedsmen in America under the names given below. The roots were harvested in due season and stored in a good root-cellar, but were not analyzed till January, 1889. For the methods of sampling and analysis reference is made to the bulletin above noted.

The varieties grown in 1888 were White Sugar Beet, Excelsior, Valmorin's Improved, and Lane's Improved. The mean weight of the first variety was 14.5 ounces; of the second, 17 ounces; of the third, 19 ounces, and of the fourth, 18 ounces. The results of the analyses of the juice of the different varieties are as follows:

Variety.	Solids, Brix at 17.5° C.	Sucrose.	Purity coef- ficient.
		<i>Per cent.</i>	
White Sugar Beet.....	19.50	14.12	73.7
Excelsior.....	16.14	12.73	78.8
Vilmorin's Improved.....	19.33	15.00	77.6
Lane's Improved.....	19.10	14.47	75.7

Professor Patrick makes the following remarks on the analyses:

These results taken by themselves lend some encouragement to the hope that the climate and soil of Iowa may prove well adapted to the development of sugar in the sugar-beet.

But a single year's trial in a single locality goes but little way in settling so great a question.

Different seasons as well as different soils will have their influence, and sometimes a marked one, on the quality of the crop. This truth, or if not this then another one which the investigator of these subjects must always bear in mind, namely, that seeds purchased from dealers are not always true to their catalogue names, is well illustrated by the results obtained in 1889 as compared with those of 1888, above recorded.

Two varieties were grown in 1889, viz, Lane's Improved and Vilmorin's Improved. The analyses were made on November 20-23. These beets were planted on the same ground as those of the previous year, but the ground had received a good dressing of barn-yard manure for the crop of 1889. The mean weights were as follows:

Lane's Improved, 42 ounces; Vilmorin's Improved, 25 ounces. The results of the analyses of the expressed juice were as follows:

Variety.	Solids, Brix, at 17.5° C.	Sucrose.	Purity, coefficient.
		<i>Per cent.</i>	
Lane's Improved.....	13.32	7.82	58.7
Vilmorin's Improved.....	17.80	12.64	71.0

The disastrous results of manuring beets with barn-yard manure are easily seen from the above table. The beets grew to an enormous size,

and were consequently low in sugar. Professor Patrick supposed that the low content of sugar was due only in part to the manuring, and he accounts for it as follows:

First, by the character of the season in 1889—dry in the early part, cold and wet toward the end—together with the enrichment of the land with barn-yard manure.

Second, and with reference to the Lane's Improved mainly, by the quality of the seed, the same having come, without doubt, from stock badly crossed with an inferior kind of beet. This conclusion is reached as much from the appearance of the beets within and without, as from the results of analysis. The similar experience of many beside ourselves makes it evident that sugar-beet seed purchased from American seedsmen is very liable to prove untrue and disappointing.

For these reasons we do not regard the results of 1889 as having any real significance in the question of the adaptability of Iowa's soil and climate to the needs of the sugar-beet.

In addition to the work done with the beets grown at the Station a box of beets was received on the 19th of November, 1889, from Mercer County, Ill., sent by Edward H. Thayer, of Clinton, Iowa. The seed from which these beets were obtained was purchased in Germany, but the names of the varieties are not known. The mean weight of the beets was 23.5 ounces. They contained of sugar 15.25 per cent in the juice, and a purity coefficient of 75.73. It is evident from the above that the beets from Illinois were grown without the use of barn-yard manure and, although a little above size, were much better in every way for the production of sugar than the beets grown at the Station.

From the results obtained, it is not difficult to see that the soil and climate of Iowa are far better suited to the growth of the sugar-beet, for sugar-producing purposes, than for sorghum. In the experiments made with sorghum at the Iowa Station, and which are given on pages 327 to 336, inclusive, of the bulletin above mentioned, the mean percentage of sucrose in the juice of the Early Amber was found to be 14.11, while the purity coefficient was 76.76. The hopelessness, however, of expecting to make sorghum sugar profitably in Iowa is sufficiently indicated by the statement made on page 328 of the bulletin, which is as follows:

On the night of September 18 there came a killing frost, which within three days withered the cane leaves and soured the sap in the stalks, thus reducing our season for selective work to only ten days.

With a season of such brief duration, which is almost certain to be ended in September, it is not to be expected that sorghum sugar can be made successfully. With the beet it is quite different, since by proper siloing the season for manufacture can be continued indefinitely.

EXPERIMENTS IN NEBRASKA.

The following report*, by Professors Nicholson and Lloyd, on the growth of the sugar beet in Nebraska from seed received from the Department of Agriculture, shows the progress made in that State during

* For full report see Bulletin 13, Nebraska Station.

the past year in the cultivation of the sugar beet under the auspices of the agricultural experiment station of the State.

REPORT ON THE DISTRIBUTION OF SEED RECEIVED BY THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF NEBRASKA, FROM THE DEPARTMENT OF AGRICULTURE, AT WASHINGTON, D. C.

Varieties received.—I. Sugar beets, Lane's Imperial and Vilmorin II. Sugar Cane, Early Amber, and Red Siberian.

But two persons reported results from sugar cane seed, in both cases a large proportion of the seed failed to germinate.

Analysis of two specimens of Early Amber cane sent in, gave, respectively, 13 and 12.41 per cent of sucrose.

In regard to sugar beets, twelve samples of seed of Lane's Imperial were sent out.

Seven persons returned specimens of beets raised accompanied by very brief reports; all reported poor seed.

Average per cent of sucrose in these beets was 4.66; highest, 6.08; lowest, 2.50.

Thirty-three samples of seed of Vilmorin were sent out.

Twenty-three persons returned to us specimens of beets raised, accompanied by brief reports which gave but little information, except that a large proportion of the seed did not germinate.

In fifteen of the beets the per cent of sucrose ranged above. Average of the fifteen specimens, 14.67; average of the eight (under 10) specimens, 6.97; average of the entire lot, 11.99; highest per cent. in whole lot, 20.28; lowest per cent. in whole lot, 4.73.

Analysis of sugar beets, chemical laboratory, University of Nebraska.

No.	Date.	Consignor.	Variety.	Sucrose.	Glucose.	Brix.	Specific gravity.	Co-efficient of purity.
				<i>Per cent.</i>	<i>Per cent.</i>			
1	Oct. 28	C. B. Kemple.....	Vilmorin	13.28	0.370	21.6	1.098	61
2	Oct. 29	H. C. Armstrong.....	do	11.49	0.010	17	1.070	68
3	do	S. M. Bates	Unknown	19.52	0.010	23.7	1.100	80
4	do	W. M. Lowman	Vilmorin	9.91	0.052	19.3	1.082	51
5	do	Ira Ford	do	10.14	0.009	20.4	1.085	50
6	Oct. 30	do	Red beet	10.13	0.017	19.3	1.080	52
7	Nov. 15	Mr. Rinker	Lane's Imperial ..	15.32	0.230	23.7	1.100	65
8	do	F. Bates .....	.....	13.51	0.100	23.7	1.100	58
9	do	S. G. Johnson .....	.....	9.69	0.160	23.7	1.100	40

H. H. NICHOLSON, *Director.*
RACHEL LLOYD, *Analyst.*

EXPERIMENTS AT GRAND ISLAND, NEBRASKA.

Great success also attended the growing of sugar beets in Nebraska, at Grand Island, in 1888. As will be seen by the following table, samples of these beets were analyzed by various chemists, and all found them excellent for sugar-making purposes.

Brix.	Sugar.	Co-efficient of purity.	Brix.	Sugar.	Co-efficient of purity.
	<i>Per cent.</i>			<i>Per cent.</i>	
*17.2	14.9	86.00	†16.0	13.71	85.70
*18.9	16.1	85.00	†17.1	14.2	83.00
*19.5	17.5	89.00	§16.3	13.10	80.40
*21.4	19.2	90.00	||18.9	15.8	83.60
*19.7	16.7	84.00	||18.2	15.20	83.50
*21.8	19.8	90.00	||18.4	15.90	86.40
†18.8	16.4	87.10			

* Analyzed by Prof. William Huch, from Shoemingen, Germany.

† Beets harvested October 15, 1888 preserved in silo, analyzed January 2, 1889.

‡ Analyzed by Dr. Pauly, of Muhlberg, Germany.

§ Analyzed by Dr. Mueller, of Otteleben, Germany.

|| Analyzed by Dr. Janke, Trendlebusch, Germany.

Samples of these beets were also sent to the Department for analysis and entered as Nos. 6077 and 6078. The results of these analyses were as follows :

	6077.	6078.
	<i>Per cent.</i>	<i>Per cent.</i>
Juice extracted.....	56.16	54.70
Total solids in juice.....	18.40	18.80
Sucrose.....	15.38	15.75
Purity.....	83.59	83.77

As will be seen by the above analyses these beets were very rich in sugar, and if they could be grown in large quantities, which there is no reason to doubt, would indicate that in that locality the beet sugar industry could be successfully established.

EXPERIMENTS IN SOUTH DAKOTA.

Experiments were made at the Agricultural Experiment Station at Brookings, which are reported in Bull. No. 16, by Luther Foster, agriculturist, and James H. Shepard, chemist.

THE SUGAR-BEET.

The Station has completed its second season's test of the sugar-beet, and the result gives us still better evidence of its crop value to South Dakota both for stock feeding and sugar making. While the crop was not as great either in per cent of sugar or yield of roots per acre as may reasonably be expected in more favorable seasons, or by following more strictly the French and German methods of fertilizing and cultivating, it was still sufficiently large to insure it a profitable crop even under the opposing influences of the past season.

Preparation of soil.—In the whole matter of soil preparation, fertilizing, and cultivating, nothing has been attempted that is not within the reach of the ordinary farmer, and our results are no better than he may reasonably expect. In mechanical preparation the soil was almost perfect for such a crop, the ground having been deeply plowed and thoroughly pulverized. The results of long-continued experiments in

beet-growing countries indicate an average depth in plowing of from 12 to 15 inches to insure the largest and best yield. Deep plowing prevents forking; it also provides a depth of mellow soil sufficient for the growth of the root entirely beneath the surface. Where beets grow partly above the soil the protruding portion becomes tinted and requires extra work in clarifying the sugar. Fall is the best time for plowing. It leaves a rough, uneven surface to weather, catch moisture, and settle. The final preparation should be made at planting time, avoiding any plowing or deep stirring that would cause a loss of the accumulated moisture of the winter. Thorough preparation before planting is of prime importance. Any neglect here will be a source of frequent annoyance and delay throughout the season of planting and cultivation. The clod-crusher and roller will greatly assist in this work.

Fertilizing.—The ground used for the experiment had received a heavy coat of well-rotted manure last year and was in excellent condition to nourish the season's crop. It is a fact well established by beet-growers that a too abundant supply of stable manure lessens the per cent of sugar. This results from a period of growth too rank and too much prolonged. To produce sugar the growth must be arrested in time for complete maturity. The dry, clear weather of this climate is favorable to this result. Stable manure should be applied and plowed under in the fall and not more than 15 tons per acre used.

Planting.—Experience has taught that the method of planting is of vastly greater importance than is ordinarily considered. It has been shown that not only the yield per acre but also the per cent of sugar depends largely on the manner of planting. Thin planting—rows wide apart and plants well separated from each other in the row—gives beets of the largest size but containing a small per cent of sugar, while the largest yield per acre both in per cent of sugar and quantity of beets is obtained from the thickest planting—rows narrow and beets close together in the row. In Dakota the high price of hand labor and cheapness of land would place the limit of thick planting to that width of row that can be easily cultivated with horse implements. That limit has been placed at 20 inches, but even 24 inches seems quite narrow for most of our single cultivators. Our planting in most cases has been made in rows thirty inches apart with the plants thinned to 8 inches apart in the row. One-half more plants can be grown with rows 20 inches apart, and with almost a half greater yield in pounds and a decidedly larger per cent of sugar. Our thickest planting was made in rows 14 inches apart with plants thinned to 6 inches apart in the row. This planting produced beets smallest in size but uniformly richest in per cent of sugar. It is generally admitted that the saccharine richness is inversely proportioned to the volume of the beet and that close planting gives beets of richer, better quality, of larger yield in weight and per cent of sugar, and at the same time exhausts the soil less.

The past season's planting was done the 10th day of May by hand. The furrows were made with an ordinary hand marker to whose runners had been attached small triangular pieces of wood to deepen and widen the marks. The furrows were $1\frac{1}{2}$ inches deep; in these the seeds were drilled with a garden seeder and covered with the hoe, the covering being well-firmed to make it hold the moisture. The porous shell encasing the seed makes an extra amount of moisture necessary to reach the real seed within and cause it to grow. In this dry climate care should be taken to put the seeds down fully an inch and a half in order to secure the moisture needed to start them. Garden seed drills when used for planting should be in the hands of skillful operators to insure satisfactory results. Hand-planting has resulted best in our work.

Germination may be hastened by soaking the seeds in hot water for twenty-four hours just before planting. They can easily be made dry enough to plant with a machine by rolling them in plaster or dry soil.

Varieties planted.—The following is a list of the varieties planted with the names of the firms from which the seeds were purchased and the price paid for them per pound. When planted with a drill from 6 to 10 pounds per acre will be required, the amount depending upon the distance the rows are placed apart. Imperial, Silisian and red-top were furnished by D. Landreth & Sons, Philadelphia, at 40 cents per pound. Vilmorins imperial, Lane's improved and white sugar came from J. C. Vaughan, Chicago, the first at 60 cents and the others at 40 cents per pound. Salzer's imperial and sweet white, John A. Salzer, of La Crosse, supplied at 20 cents per pound.

In some instances the varieties are the same, no doubt, with different names.

Cultivation.—Early cultivation will kill the weeds at starting and form a layer of mellow earth which constitutes an obstacle to dryness.

The loosened layer acts as a mulch and tends to keep the soil below cooler while it prevents the water from reaching the surface to be evaporated.

The crop of the past season was twice hoed and four times cultivated. The implement used for the latter was an adjustable spring-tooth cultivator. This work began soon after the plants were up and continued until the middle of July.

Thinning.—This work can best be done just after a rain. The plants should be thinned to the proper distance in the row before the roots begin to develop. Where the planting is done with a drill, a sharp hoe may be used for thinning. The cutting must be deep enough to prevent any after growth of the roots cut off. In case the extra plants are pulled out, care should be taken not to loosen those that remain standing and thus check their growth. If the weather is favorable at the time of thinning the blank places may be filled in by transplanting,

but the roots of the latter are usually found in several divisions instead of a single tap root.

Harvesting.—The crop should be palled and stored in the root cellar or put in piles convenient for covering in the field before there is any danger of injury from freezing. In this respect they require more attention than other root crops. A temperature low enough to freeze the surface of the ground will destroy their keeping qualities. Beets injured in this manner should be fed out at once that they may not be an entire loss. Though the injury may seem at first very slight experience has shown us that they soon become spongy, then turn black, and finally rot. The usual plan of twisting off the tops as the beets are pulled has proven in our experience the safest and most economic method. While turnips, rutabagas, and carrots are not materially injured for keeping by having the root cut or broken, a beet so injured is apt to decay when stored.

Storing.—Sugar-beets and mangles require the same treatment in storage.

They should be placed in cool, moist cellars, making the piles not to exceed 4 feet in depth. In our dry Dakota cellars it is best to cover with damp earth to keep them from wilting. This will also help to protect from freezing. The dirt must be put directly on the beets, no straw or litter of any kind intervening. In this way we have kept them in the best condition into May.

VALUE FOR STOCK-FEEDING.

For feeding, the sugar-beet and mangle are the most reliable of all the root crops. Taken as a whole they have fewer enemies and are less liable to failure than almost any other crop grown in the State.

They are less liable to disease than either rutabagas or turnips, and less easily affected by drought. They also surpass them for feed in per cent of digestible nutrients. When the feeding value of 100 pounds of sugar-beets is 19 cents, that of 100 pounds of rutabagas is 15 and of turnips only 11 cents.

When properly stored they keep in good condition for feeding longer than any other root crop, under favorable circumstances keeping clear through the feeding season until the grass is ready to pasture in the spring. Both the feeding and keeping qualities depend upon complete maturity. Bulk of crop is not the only thing to be sought, neither are roots of unusually large size desirable. For the most satisfactory results in feeding, seek rather the weight in many roots of medium size perfectly ripened. Roots can not be relied on to supersede either hay or grain, but by being fed with them they greatly increase the value of both. Their succulence makes them an excellent stomach regulator, preventing the constipation that frequently comes from the continued use of dry foods. It is this quality, too, that makes them of special value to the dairyman for keeping up the flow of milk. They replace

to a large degree the green succulent food of summer. All the stock on the farm relish sugar beets in winter. Sheep do excellently on them, and the greater part of their winter's supply of food may come from this source. A quantity should always be kept for ewes that wean their lambs before the grass starts. It should be noted, however, that for some time before the lambs come the ewe's ration of roots should be small since it is generally conceded that a full supply at this time has a tendency to produce abortion.

Hogs kept through the winter for breeding purposes should have a daily allowance of cut or pulped beets in connection with their dry food. They can thus be more economically kept, and they come through the winter healthier and in every way better prepared to farrow and raise their pigs. In all cases the roots fed should be cut into pieces small enough to prevent choking. A spade may be used for this purpose, but a root cutter is more convenient and does the work better and much more rapidly.

The beets were analyzed the last week in October. All the samples were in good condition. Samples 10, 11, and 12 were of the same variety, and were planted in different widths of rows and at different distances apart in the row. No. 11 was planted in rows 30 inches apart and thinned to 8 inches. No. 11 was thinly planted and No. 12 was planted very thickly. From an inspection of the table which follows it will be seen that the sugar yield depends largely on the manner of planting, other things being equal. It will also be interesting to compare the yield of sugar with the size of the beets:

[Four beets taken in each sample.]

	Weights.			
	No. 1.	No. 2.	No. 3.	No. 4.
	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.
Sample 8.....	0 12	1 $\frac{3}{4}$	1 10 $\frac{3}{4}$	2 2 $\frac{1}{2}$
9.....	0 10 $\frac{3}{4}$	2 4 $\frac{1}{2}$	2 10 $\frac{1}{2}$	2 14 $\frac{1}{2}$
10.....	0 11 $\frac{1}{2}$	1 5 $\frac{1}{2}$	2 12	3 13 $\frac{1}{2}$
11.....	2 13	4 13	7 15 $\frac{3}{4}$	15 8 $\frac{1}{2}$
12.....	1 13 $\frac{3}{4}$	1 8 $\frac{1}{2}$	1 14 $\frac{1}{2}$	2 7 $\frac{1}{2}$
13.....	1 $\frac{3}{4}$	1 15 $\frac{1}{2}$	3 4 $\frac{1}{2}$	5 4 $\frac{1}{2}$
14.....	0 9 $\frac{1}{2}$	1 6	2 2	3 14 $\frac{1}{2}$
15.....	1 2 $\frac{1}{2}$	1 13	2 7	4 7 $\frac{1}{2}$
16.....	0 15 $\frac{1}{2}$	2 3 $\frac{1}{2}$	2 9 $\frac{1}{2}$	5 12 $\frac{1}{2}$
17.....	0 13 $\frac{3}{4}$	0 15	1 13 $\frac{3}{4}$	2 14

In selecting samples for analysis, twelve beets of each variety were sent to the laboratory. These ranged from the smallest to the largest average beet which the variety afforded. At the laboratory four piles were made and from each pile an average beet was taken, thus securing a fair representation for each sample.

In obtaining the degree Brix, the pulp was placed in a canvas bag and the juice was forced out by hand. No press was available.

Station No. of sample.	Name.	Stand.	Yield per acre.	Sucrose.	Density of juice (Brix).	Marc.	Condition of pulp.
		<i>Per ct.</i>	<i>Lbs.</i>	<i>Per ct.</i>		<i>Per ct.</i>	
8	Silesian	75	23,600	10.0	14.2	3.76	Dry.
9	White	94	27,900	8.2	12.4	3.00	Somewhat dry.
10	Lane's Improved (ordinary planting).	88	31,200	10.2	15.3	3.56	Do.
11	Lane's Improved (thinly planted) ..	50	14,840	5.4	10.4	3.12	Moderately dry.
12	Lane's Improved (thickly planted) ..	50	16,680	9.9	15.2	3.63	Dry.
13	Red Top	75	23,850	10.2	15.1	3.85	Do.
14	Imperial	67	15,320	9.9	14.0	3.94	Do.
15	Vilmorin's Imperial	75	25,400	12.3	17.4	4.10	Do.
16	Salzer's Imperial	88	29,070	11.0	14.6	3.27	Moderately dry.
17	Sweet White	63	32,500	11.2	15.6	3.91	Dry.

Again hope is expressed that farmers will raise small quantities of the sugar-beet. All samples delivered at the Station laboratory will be analyzed free of charge.

Samples which had been harvested for three months were sent to the Department from Sturgis, S. Dak., in January, 1889, and entered under No. 6162, a rose-colored beet, and No. 6163, a white beet. These samples were sent by W. C. Buderus, of Sturgis, S. Dak. On examination of these beets the following numbers were obtained :

	6162.	6163.
	<i>Per cent.</i>	<i>Per cent.</i>
Juice extracted	36.05	42.77
Total solids in juice	20.40	21.48
Sucrose	13.32	15.03
Purity	65.29	69.97

The low purity of the beets represented above was doubtless due to the fact that they had been harvested for a long time and no precautions taken to preserve them from deterioration. The analyses show that such beets could also be profitably used for sugar-making if worked up in a fresh state or preserved in proper kinds of silos.

EXPERIMENTS IN KANSAS.

The Medicine Lodge Sugar Company last year (1889) made a series of experiments in the growth of sugar beets and the manufacture of sugar, the details of which follow :

Number of acres planted in beets	4.7
Tons of topped and cleaned beets produced	60.23
Pounds of sugar made	10,158
Gallons of molasses obtained	380

Of the total sugar made, 2,800 pounds were second sugars.

The beets did not receive altogether the attention which they should have had, and many of them grew quite a distance above ground. The beets were worked without any special appliances, but solely with

the sorghum machinery which was at the factory. For this cause it is reasonable to suppose that the best manufacturing results were not obtained. Nevertheless, the results are gratifying, and show that with such a season as last, sugar beets can be grown in Kansas with a fair percentage of sucrose. In many cases the beets grown last year were of extraordinary size, in one instance weighing 12 pounds. By more careful preparation of the soil, and planting the beets closer together, and proper cultivation, it is reasonable to believe that a higher mean content of sugar might be obtained. The details of the analyses of the beets, by Mr. T. F. Sanborn, of this division, and the manufacture thereof are found in the following table:

Medicine Lodge, Kansas, season of 1889.—Sugar beets.

	Date.	Serial No.	Degree Brix.	Sucrose in the juice.	Purity.
Exhausted chips	Nov. 14	264	1.60	<i>Per cent.</i> .62	38.75
Do	Nov. 15	269	2.24	.82	32.14
Mean			1.92	.72	35.44
Fresh chips	Nov. 14	265	13.74	9.00	65.50
Do	Nov. 15	270	12.09	9.67	71.71
Mean			12.92	9.32	68.60
Diffusion juice	Nov. 14	266	10.83	7.88	72.76
Do	Nov. 15	271	10.99	7.37	67.15
Mean			10.91	7.62	69.95
Clarified juice	Nov. 14	267	11.64	7.77	66.58
Do	Nov. 15	273	10.65	6.35	59.62
Mean			11.14	7.06	63.10
Semi-sirup	Nov. 14	268	29.32	18.80	64.12
Do	Nov. 15	274	25.26	18.10	71.61
Mean			27.29	18.45	67.87
Masse cuite	Nov. 16	22	77.71	34.04	43.82
Do	Nov. 24	24	85.68	49.51	57.78
Mean			81.69	41.77	50.80
Marc	Nov. 14			4.69	
Do	Nov. 15			5.01	
Mean				4.85	

	Sucrose.
Nov. 15. Scum from clarifiers	per cent.. 5.00
Nov. 15. Scum from clarifiers, less lime	per cent.. 3.00

POLARIZATION OF SUGARS.*

Date.	Serial No.	Sucrose.
November 19.	16	<i>Per cent.</i> 90.9
November 24.	17	99.7
Mean		95.3

* Sugar not washed. No. 16, reboiled.

Miscellaneous samples of beets from field.

Date.	Serial No.	Degree Brix.	Sucrose in the juice.	Purity.
			<i>Per cent.</i>	
Aug. 23	7	19.62	14.58	74.31
Sept. 2	62	11.01	7.25	65.88
3	64	12.69	9.25	78.81
4	70	10.20	6.95	68.23
13	120	15.58	11.75	75.42
21	190	18.66	11.75	62.96
Nov. 8	306	13.75	9.35	68.00
11	317	15.59	11.00	70.55
12	318	13.55	9.35	69.00
12	319	16.28	13.10	80.46
12	320	16.80	13.95	81.84
12	321	14.26	10.40	72.93
12	322	16.17	12.65	78.23
Maximum		19.62	14.58	81.84
Minimum		10.20	6.95	62.96
Mean		14.93	10.85	72.64

Mr. Fred Hinze cultivated an experimental plot of sugar beets at Douglass, Kans., during the season of 1888. Considering the dryness of the climate and the high temperature reached during the summer, the results appear to be favorable. I am inclined to think, however, that the successful cultivation of the sugar beet for manufacturing purposes can not be looked for in such a climate as obtains at Douglass in competition with more favorable localities.

The analyses of the sugar beets at this station were made from time to time by my assistants at Douglass who had charge of the chemical work at the sorghum factory at that place. Following are the results of the work:

Date.	Degree Brix.	Sucrose in the juice.	Coefficient of purity.
		<i>Per cent.</i>	
Sept. 3	13.58	9.27	67.64
3	11.67	7.96	68.30
3	12.45	8.16	65.46
10	16.74	12.38	73.96
20	14.70	9.47	64.42
29	14.43	10.47	72.69
Oct. 11	15.95	11.98	75.11
Highest	16.74	12.38	75.11
Lowest	11.67	7.96	64.42
Average	14.22	9.36	69.65

EXPERIMENTS IN CALIFORNIA.*

The Alvarado, Cal., beet-sugar factory is situated on the east side of the bay, 24 miles from San Francisco.

The climate of Alvarado is a peculiar one, and, as experience has shown, very suitable to the development of a first-class sugar beet.

The winters are mild. Planting begins in February and can be continued up to the middle of May. The early planting matures in the

* Bull. No. 5, pp. 75 *et seq.*

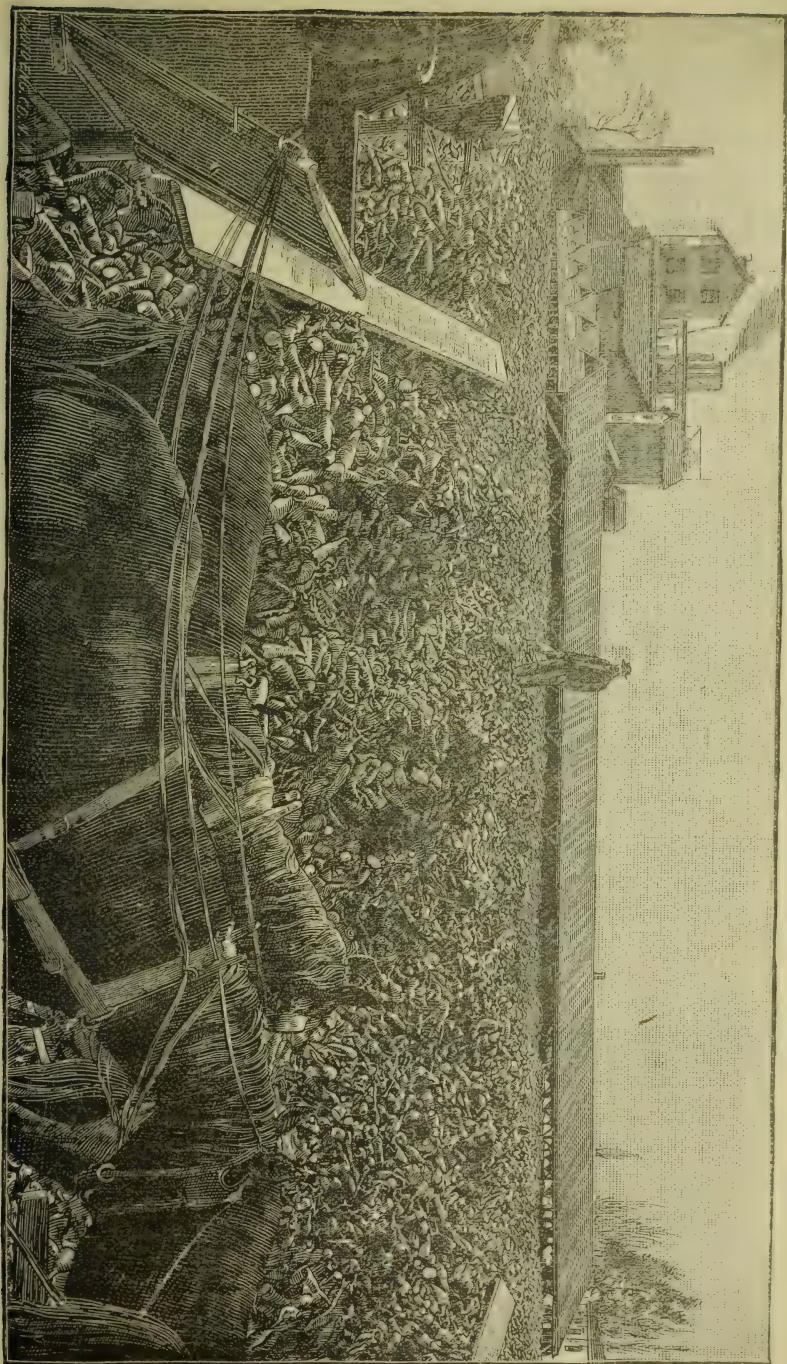


FIG. 43.—Sugar-Beets (nearly 20,000 tons), Alvarado, Cal.*

* From Sugar Industry of the United States, p. 77. Bulletin No. 5, Chemical Division, U. S. Department of Agriculture.

summer and the factory can be started by the middle of August. From this time until December there is a consecutive maturity of beets. The summers and falls are dry, and there is little danger of the beets taking a second growth by reason of early rains.

When harvested the beets do not require to be siloed, but are kept in heaps either with no covering at all or at most a little straw.

In the middle of December, 1884, the company had nearly 20,000 tons of beets on hand.

In Fig. 43 is seen this immense pile of beets, covering over 2 acres of surface and of 8 feet mean depth.

The land on which these beets are grown is level, the soil sandy and fertile, stretching from the bay eastward to the hills, a breadth of from 5 to 10 miles.

The following tables, prepared at my request by Mr. E. Dyer, superintendent of factory, exhibit the data collected from twelve different fields, representing a fair average of all the land in cultivation for beets in 1884.

The analyses represent a fair sample of beets taken from all the wagons during each day the beets were brought to the factory. The kind of seed used is also indicated in the tables.

Formerly all the seed planted was imported, but the company is now raising its own seed, and with the most encouraging results.

The expression "first and second year" indicates that the seed was native and one or two years from the imported seed.

In all the analyses made at Alvarado the sucrose is calculated on the weight of the beet and not of the juice.

FIELD OF JOHN LOWRIE.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Coefficient of purity.	Remarks.
1884.		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	
Sept. 10	Native red, first year	15.9	13.4	2.5	84.2	Planted 315 acres; not all harvested yet; will average between 15 to 20 tons per acre.
15	Native white, second year	16.9	13.9	3.	82.2	
20	Native red, first year	17.3	14.9	2.4	86.1	
25	do	17.9	15.6	2.3	85.7	
30	do	17.2	15.1	2.1	87.7	
Oct. 1	do	18.5	15.7	2.1	84.8	
5	do	17.7	14.7	3.	83.	
10	do	17.8	15.5	2.3	87.6	
15	do	17.	14.4	2.6	84.7	
20	do	16.6	14.	2.6	84.	
24	do	13.7	12.6	3.1	80.	
28	do	17.4	14.3	3.1	82.1	
Nov. 9	do	16.5	13.5	3.	81.2	
13	do	14.8	11.5	3.3	77.1	
16	do	14.5	12.5	2.	86.2	
18	do	13.	10.4	2.6	80.	
22	Native white, second year	17.	14.9	2.4	87.6	
24	Native red, first year	16.2	13.7	2.5	84.5	
Dec. 5	do	15.4	13.2	2.2	85.7	
10	do	15.6	13.2	2.4	84.4	

FIELD OF B. AZEVADA

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Co-efficient of purity.	Remarks.
1884.		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	
Nov. 5	Native white, second year	17.	14.	3.	82.9	Planted 10 acres; had 152.8 tons; yield per acre, 15.3 tons.
6	Native red, first year	16.2	13.2	2.4	85.1	
9	do	16.8	14.3	2.3	86.3	
13	Native white, second year	17.4	15.4	2.	88.5	

FIELD OF JAMES NARCISSE.

Oct. 23	Native white, second year	16.1	13.1	3.	81.3	Planted 10 acres; had 237 tons; yield per acre, 23.7 tons.
Nov. 5	do	16.5	13.6	2.9	82.4	
7	do	15.2	13.	2.2	85.1	
13	do	15.2	13.2	2.9	80.9	
20	do	16.9	13.5	3.4	79.8	
23	do	17.1	14.3	3.8	83.6	
24	do	15.6	12.8	2.	82.	

FIELD OF J. G. VANDEPEER.

Oct. 21	Native white, second year	16.8	13.9	3.1	82.7	Planted 20 acres; had 360 tons; yield per acre, 18 tons.
24	do	17.9	15.	2.9	83.2	
Nov. 1	do	15.6	13.5	2.1	86.5	
3	do	17.8	15.1	2.7	84.4	
4	do	15.2	12.5	2.7	82.2	
6	Native red, first year	14.3	12.	2.3	83.9	
7	do	14.2	12.	2.2	84.	
13	Native white, second year	17.2	14.3	2.9	83.1	
15	Native red, first year	14.2	12.	2.2	84.5	
17	Native white, second year	18.	16.1	2.4	87.5	
24	do	17.	14.	3.1	82.3	
26	do	16.3	14.	2.3	85.9	

FIELD OF FRANK MUNYAR.

Nov. 1	Native white, second year	16.2	13.9	2.3	85.	Planted 12 acres; had 246 tons; yield per acre, 20.5 tons.
6	do	15.6	13.	2.6	83.3	
9	Native red, first year	16.8	14.	2.8	83.3	
11	do	16.9	14.2	2.7	84.	
19	do	15.2	12.6	2.6	80.7	

FIELD OF M. BAIN.

Oct. 24	Native red, first year	17.3	14.5	2.8	83.	Planted 18 acres; had 414 tons; yield per acre, 23 tons.
24	Native white, second year	18.4	15.8	2.6	85.9	
31	Native red, first year	15.2	12.	3.2	78.9	
31	do	16.2	14.	2.2	86.4	
Nov. 2	do	16.8	14.7	2.1	86.3	
5	do	16.9	14.7	2.2	86.	Planted 18 acres; had 414 tons; yield per acre, 23 tons.
6	Native white, second year	16.9	14.2	2.7	83.7	
7	Native red, first year	15.	12.4	2.6	82.	
10	do	17.2	14.5	2.7	84.3	
15	do	17.2	15.	2.2	87.2	
18	do	16.7	14.5	2.2	86.8	

FIELD OF A. GEORGE.

Oct. 21	Native white, second year	15.2	12.	3.2	79.	Planted 10 acres; had 153.8 tons; yield per acre, 15.3 tons.
29	Native red, first year	14.6	12.1	2.5	82.8	
1	do	14.5	11.5	3.	79.3	
9	do	14.6	12.	2.9	82.1	
16	Native white, second year	16.1	14.	2.1	86.9	
18	do	16.7	13.1	3.6	78.4	

FIELD OF A. P. MACHADE.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Coefficient of purity.	Remarks.
1884.		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>		
Oct. 24	Native white, second year.....	16.3	13.7	2.6	84.6	Planted 8 acres; had 152 tons; yield per acre, 19 tons.
28	do.....	17.4	14.7	2.7	84.6	
Nov. 1	do.....	17.4	15.3	1.9	89.6	
5	do.....	16.3	14.	2.2	86.4	
10	do.....	14.	11.6	2.4	82.5	
13	do.....	14.6	12.5	2.1	85.6	

FIELD OF FRANK GEORGE.

Oct. 21	Imported white Imperial	18.3	15.5	2.8	84.7	Planted 10 acres; had 175 tons; yield per acre, 17.5 tons.
23	do.....	16.8	13.	3.8	77.3	
Nov. 2	do.....	16.2	12.9	3.3	79.6	
5	do.....	15.9	13.	2.9	81.6	
10	do.....	15.5	13.	2.5	83.8	

FIELD OF A. GASPER.

Oct. 21	Imported white Imperial	16.6	13.	3.6	78.3	Planted 7 acres; had 105 tons; yield per acre, 15 tons.
28	do.....	16.2	13.8	2.4	85.	
Nov. 10	do.....	15.7	13.	2.7	82.8	
14	do.....	16.4	14.5	1.9	88.4	

FIELD OF JAMES FIRERA.

Oct. 24	Imported white from Fred. Knauer Germany.....	15.3	12.5	3	80.1	Planted 5 acres; had 130 tons; yield per acre, 26 tons.
24	do.....	15.2	11.5	2.7	75.5	
Nov. 4	do.....	16.4	12.8	3	78	
11	do.....	15.6	12.3	2.1	80.1	
13	do.....	16.5	13.3	3.2	80.6	
19	do.....	14.2	10.2	4	91.8	
20	do.....	13.7	9.1	4.8	66.4	

FIELD OF FRANK P. ROSE.

Oct. 24	Native, red, first year.....	19.2	17	2.2	88.5	Planted 20 acres; had 474 tons; yield per acre, 23.7 tons.
24	Imported, white.....	16	13.6	2.4	85	
25	do.....	17.3	13.2	3.5	78	
30	Native, red, first year.....	16.5	13.8	2.7	83.6	
Nov. 15	do.....	17.6	15.3	2.3	86.9	
16	do.....	17.3	15	2.3	86.6	
19	do.....	16.5	13.8	2.7	83.6	
24	do.....	16.3	13	3.3	79.8	

TABLES OF WORK AT FACTORY FOR EACH WEEK FROM SEPTEMBER 16
TO NOVEMBER 11.

Mr. E. F. Dyer also kindly furnished me with the following data illustrating the workings of the factory in detail for nine consecutive weeks.

These tables contain a large amount of most practical information as well as valuable scientific data.

EXPLANATION OF TABLES.

The analyses were made daily, and these are given as well as the mean for the week. The column headed "Diffusions" gives the number of diffusion cells filled each day. The degree Brix represents the per cent. total solids in the juice. The polarization gives the percentage of sucrose in the juice. This subtracted from the total solids gives the *difference* or solids not sucrose.

The percentage of sucrose divided by the percentage of total solids gives the "quotient" or co-efficient of purity.

The columns under "Filtration" show the density and alkalinity of the juice and semi-sirup as they come from the filter presses.

The loss of sugar in the pulps and waste waters is also given.

The percentage of lime carbonate in the animal charcoal when it is taken out for washing and reburning is also given. Last of all are the analyses of the melada as it comes from the strike pan on its way to the centrifugal. The summary gives the tons of beets worked per week and the yield of pure granulated sugar in percentages of the beets worked.

Record of working of Standard Sugar Refinery.

WEEK ENDING SEPTEMBER 16, 1884.

Date.	Cossettes per 100 of juice.				Diffusion juice.		Saturation.		Filtration.				Loss per 100.			Char.		Melada.	
	Dif- fu- sions.	Deg. Brix.	Su- crose.	Diff.	Quot.	Deg. Brix.	Su- crose.	I. Al- kalin- ity.	II. Alka- linity.	First.		Second.		Pulp.	Waste water.	Slime.	Ca CO ₃ .		
										Deg. Brix.	Alk.	Unfiltered.	Filtered.						
																			Deg. Brix.	Alk.	Deg. Brix.	Alk.
10.....	71	15.9	13.4	2.5	84.2	12.8	10.4	81.1	Per ct.	Per ct.	9.7	0.084	43.7	41.8	Per ct.	Per ct.	Per ct.	Per ct.	
11.....	69	16.6	13.3	3.3	80.1	12.9	10.3	79.8	0.168	0.123	15.9	0.092	48.5	47.6	0.151	0.4	1.4	.....	
12.....	67	17	14.6	2.4	84.3	12.8	10.2	80.7	0.210	0.182	13.4	0.070	47.5	45.0	0.106	0.2	1.2	.....	
13.....	67	16.8	13.6	3.2	82.6	13.2	10.5	82.6	0.182	0.082	13.4	0.070	47.5	45.0	0.095	0.15	0.1	.....	
14.....	69	16.9	14.1	2.8	83.4	12.7	10.5	82.2	0.173	0.143	13.5	0.080	49.5	47.8	0.077	0.1	1.6	.....	
15.....	75	16.9	13.9	3	82.2	13.2	10.3	78.0	0.200	0.196	13.1	0.098	49	46.2	0.070	0.1	1.7	.....	
16.....	74	17.6	15.2	2.2	86.3	12.4	10	80.6	0.142	0.184	11.8	0.075	51	49.3	0.159	0.3	.....	.....	
									0.187	0.176	11.6	0.061	49.1	44.8	0.097	0.1	1.3	.....	
Average		16.7	14.0	2.7	83.2	12.8	10.3	80.7	0.186	0.152	12.7	0.080	48.3	45.2	0.107	0.19	1.2	.....	
																	14.8	11.35	82.5

Tons of beets worked, 565. Per cent. of first product obtained, 9.5.

WEEK ENDING SEPTEMBER 23, 1884.

17.....	70	17.4	14.9	2.5	85.6	11.9	9.7	81.5	0.201	0.187	10.9	0.084	48.9	0.187	46.2	0.071	0.15	0.55	.....	14	12.2	.....
18.....	75	17.1	14.1	2.7	84.2	12.8	10.5	82	0.224	0.196	11.8	0.067	50.9	0.226	47.9	0.148	0.15	0.75	.....	.....	.....	.....
19.....	69	16.7	14	2.7	83.2	12.7	9.7	76.3	0.204	0.177	13.1	0.096	47.9	0.220	46	0.129	0.2	1.6	.....	14.9	9.4	.....
20.....	72	17.3	14.9	2.4	86.1	12.3	9.9	80.4	0.239	0.198	15.2	0.082	47.9	0.250	43.7	0.100	0.2	1.5	.....	7.03	.....	.....
21.....	71	17.6	15.5	2.1	81	13.4	11.2	83.8	0.223	0.190	15.2	0.091	47.3	0.198	43.7	0.118	0.3	1.7	.....	.....	.....	83.5
22.....	71	17.2	14.9	2.3	86.6	13.7	11.4	85.1	0.259	0.218	15.7	0.091	47.3	0.165	45.1	0.150	0.3	1.5	.....	15.2	11.7	.....
23.....	72	17.7	15.3	2.4	86.4	13.3	11.1	83.4	0.220	0.179	14.4	0.124	50.7	0.124	48.3	0.193	1.2	1.5	.....	12.2	.....	.....
Average.....	.....	17.2	14.8	2.4	85.5	12.8	10.5	81.7	0.224	0.192	13.6	0.087	49.1	0.195	46.2	0.129	0.34	1.30	.....	7.34	14.7	11.1
																						83.5

Tons of beets worked, 565. Per cent. of first product obtained, 9.64.

WEEK ENDING SEPTEMBER 30, 1884.

24	78	16.2	14.0	2.2	86.4	13.4	10.6	79.1	0.212	0.187	15.1	0.091	46.8	0.220	44.3	0.128	0.6	1.7	.....	13.3	11.4	83.05	.....	
25	72	17.9	15.6	2.3	85.7	13.6	11.0	80.9	0.234	0.179	15.8	0.138	46.4	0.223	43.1	0.149	0.2	1.5	.....	.....	.....	.....	.....	
26	64	17.4	15.1	2.3	84.7	13.0	11.3	86.1	0.182	0.231	16.2	0.091	47.1	0.242	45.2	0.165	0.5	1.8	.....	.....	14.7	11.4	.....	
27	78	16.6	14.5	2.1	87.3	14.2	12.0	86.4	0.262	0.220	16.0	0.134	.....	.....	.....	0.198	0.5	1.2	.....	.....	.....	.....	.....	
28	68	17.9	15.9	2.0	88.8	13.4	11.8	87.1	0.234	0.176	15.2	0.102	47.3	0.203	44.0	0.160	0.7	1.1	.....	.....	.....	81.7	.....	
29	73	17.6	15.4	2.2	87.5	12.8	10.7	83.5	0.158	0.138	14.9	0.082	46.9	0.234	46.8	0.171	0.9	1.6	.....	.....	15.63	12.59	.....	
30	72	17.2	15.1	2.1	87.5	13.5	11.1	82.2	0.248	0.176	.....	0.091	.....	0.135	.....	0.165	.....	1.4	.....	.....	.....	81.0	.....	
Average		17.2	15.0	2.1	86.8	13.4	11.2	83.3	0.218	0.186	15.5	0.102	47.3	0.231	44.6	0.155	0.5	1.4		8.59	14.54	11.79	82.06	

Tons of beets worked, 566.72. Per cent. of first product obtained, 9.54

WEEK ENDING OCTOBER 7, 1884.

1	62	18.5	15.7	2.1	84.8	14.5	13.2	83.7	0.248	0.175	13.6	0.091	50.8	0.256	48.7	0.151	0.10	1.2	10.63	15.21	12.97	82.8	
2	65	17.0	14.6	2.4	85.8	14.3	11.5	80.4	0.242	0.165	13.6	0.088	50.8	0.251	47.3	0.171	0.30	0.5	9.06	11.16			
3	74	18.1	15.0	3.1	83.4	14.3	12.2	85.3	0.171	0.096	14.6	0.0828	48.9	0.181	47.5	0.171	0.15	0.10	.....	12.2	83	.....	
4	68	17.7	15.2	2.5	85.8	13.9	11.9	83.6	0.194	0.160	14.6	0.102	50.0	0.187	45.0	0.170	0.6	0.8	9.63	.....	.....	.....	
5	72	17.7	14.7	2.0	83.0	14.1	11.6	82.2	0.234	0.160	15.3	0.082	47.2	0.151	44.9	0.123	0.3	0.7	.....	.....	.....	.....	
6	64	17.9	15.2	2.7	84.8	14.7	12.2	85.6	0.198	0.165	17.0	0.086	44.5	0.100	44.5	0.151	0.3	0.35	.....	12.23	14.42	83	
7	61	16.6	14.4	2.2	86.8	14.1	11.1	78.7	0.234	0.123	15.1	0.089	45.3	0.124	40.8	0.082	0.2	1.10	9.52	.....	.....	.....	
Average		17.6	14.9	2.7	84.0	14.3	11.8	81.8	0.217	0.149	14.8	0.0786	48.2	0.187	45.5	0.144	0.27	0.67	9.72	13.65	13.09	82.9	

Tons of beets worked, 521.92. Per cent. of first product obtained, 9.7.

WEEK ENDING OCTOBER 14, 1884.

8	70	17.0	14.4	2.6	84.7	14.3	12.0	83.2	0.220	0.209	15.2	0.109	44.9	0.157	44.8	0.110	0.10	0.3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
---	----	------	------	-----	------	------	------	------	-------	-------	------	-------	------	-------	------	-------	------	-----	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--

Tons of beets worked, 476. Per cent. of first product obtained, 11.1

Record of working of Standard Sugar Refinery—Continued.

WEEK ENDING OCTOBER 21, 1884.

Date.	Cossettes per 100 of juice.				Diffusion juice.		Saturation.		Filtration.			Loss per 100.		Char.	Melada.		
	Dif- fu- sions.	Deg. Brix.	Su- crose.	Diff.	Quot.	Deg. Brix.	Su- crose.	I. Al- kalin- ity.	First.		Second.		Waste water.	Slime.	Ca CO ₂ .		
									Deg. Brix.	Alk.	Unfiltered.	Filtered.					Deg. Brix.	Alk.
15.....	74	17.0	14.4	2.6	84.7	13.7	11.0	80.5	Perct.	15.2	0.140	46.7	Perct.	0.30	Perct.	13.12	.....
16.....	64	16.4	13.8	2.6	84.1	13.7	11.0	80.3	0.170	15.8	0.124	47.8	0.30	0.3	.....	.....	.....
17.....	63	16.9	14.1	2.8	83.1	13.8	9.1	76.5	0.150	15.8	0.096	47.1	0.25	0.1	.....	.....	.....
18.....	71	.....	.....	.....	.....	.....	.....	.....	0.096	15.0	0.096	47.1	0.242	1.2	82.3	.....	.....
19.....	80	17.3	14.7	2.6	84.9	13.0	9.5	73.0	0.182	14.6	0.126	44.5	0.303	0.5	.....	.....	.....
20.....	75	16.6	14.0	2.6	84.0	12.6	9.5	78.1	0.176	14.1	0.138	47.2	0.317	0.9	.....	16	81.6
21.....	77	16.4	13.3	3.1	81.0	12.9	10.5	81.5	0.176	14.7	0.121	47.5	0.317	1.1	8.2	12.6	.....
Average.....	.....	16.8	14.0	2.8	83.3	13.3	10.1	75.9	0.191	14.7	0.124	46.8	0.207	0.08	7.63	14.56	81.9

Tons of beets worked, 564.4. Per cent. of first product obtained, 9.9.

WEEK ENDING OCTOBER 28, 1884.

22.....	74	16.0	12.9	3.1	80.6	12.2	9.0	73.7	0.176	14.7	0.121	47.5	0.173	0.50	Perct.
23.....	69	14.8	11.7	3.1	79.0	12.2	8.8	72.1	0.168	14.9	0.090	47	0.171	0.10	Perct.
24.....	69	14.8	12.3	2.5	83.0	11.7	9.4	80.3	0.165	13.8	0.108	46.9	0.151	0.20	Perct.
25.....	76	14.1	11.6	3.0	82.2	12.8	9.4	73.4	0.171	15.6	0.085	47.3	0.154	0.20	84
26.....	73	15.9	12.9	2.9	81.1	12.2	9.2	75.4	0.182	13.8	0.082	47.3	0.126	0.15	Perct.
27.....	74	16.5	13.6	2.5	82.4	11.8	9.0	76.2	0.169	14.0	0.080	45.9	0.126	1.0	Perct.
28.....	80	15.4	12.8	2.6	83.1	11.2	8.2	73.2	0.193	14	0.069	46.8	0.114	0.30	85.5
Average.....	.....	15.4	12.5	2.9	81.1	12.0	9.0	75.0	0.173	14.3	0.091	47.0	0.145	0.23	Perct.
											42.2	0.242	7.99	13.4	83.7

Tons of beets worked, 576.3. Per cent. of first product obtained, 9.3.

ANALYSIS OF CALIFORNIA BEETS MADE BY THE BUREAU OF CHEMISTRY AT WASHINGTON.

In order to render the results of the analyses made by Mr. E. H. Dyer more emphatic, I selected ten samples of beets, some from wagons as they were unloading, and some from the large pile of beets on hand, and sent them to Washington for examination.

The results of the analyses of these beets are given in the following table:

Analyses of California beets.

Variety.	Number.	Number of beets.	Weight in grams.	Per cent. of juice extracted.	Specific gravity.	In juice.		Total solids calculated.	Total solids weighed.	Per cent. ash.	Co-efficient calculated.	Co-efficient found.
						Per cent. of reducing sugar.	Per cent. of sucrose.					
Imperial Rose	1	8	4,237	51.80	1.071	.190	14.46	17.23	17.41	1.136	83.9	83.1
Imperial White	2	7	4,359	65.61	1.068	.084	13.59	16.53	16.23	.930	83.2	83.7
Imperial or White Silesian	3	7	4,565	59.08	1.070	.082	14.69	17.01	17.13	1.134	86.4	85.8
White Silesian	4	8	3,555	58.41	1.074	.057	15.85	17.92	18.29	.822	88.5	86.7
Imperial	5	8	2,902	64.13	1.063	.069	14.92	15.39	17.40	.844	96.9	85.7
Improved Imperial Red	6	6	3,490	65.07	1.069	.061	13.59	16.77	17.60	.956	81.0	77.2
White Imperial	7	6	3,285	62.34	1.075	.129	15.19	18.14	18.40	1.009	83.7	82.6
Imperial Rose	8	7	3,585	66.63	1.063	.075	13.65	15.39	15.62	1.233	88.7	87.3
White Imperial	9	6	3,253	62.68	1.062	.109	12.71	15.16	15.29	.928	83.8	83.1
White Imperial	10	8	3,530	58.06	1.067	.050	15.19	16.30	18.58	.950	93.2	82.1
Means .....	.....	.....	3,675	61.38	.....	.91	14.38	16.58	17.20	.994	86.9	83.7

REMARKS.—No. 1, Imperial Rose; in sheds from October 15 to November 20. No. 2, Imperial White; native seed, two years; wagon. No. 3, Imperial or White Silesian; in sheds from October 15. No. 4, White Silesian; native seed, two years; wagon. No. 5, Imperial; native seed, one year. No. 6, Improved Imperial Red; native seed, one year; wagon. No. 7, White Imperial; native seed, two years; wagon. No. 8, Imperial Rose; native seed, one year; wagon. No. 9, White Imperial; native seed, two years; wagon. No. 10, White Imperial; wagon.

REMARKS ON PRECEDING TABLES.

The richness of the beets worked during the nine weeks is fully equal to the average European standard.

Thirteen per cent. of sucrose indicates a kind of beet that can be successfully manufactured.

The yield of pure granulated sugar, designated as "first product," is for the nine weeks nearly 9.5 per cent., or 190 pounds of sugar per ton of beets. This large yield is obtained by remelting the second sugars and working the solution with the fresh juices. This method gives a maximum of "first product," no second product at all, and scarcely any in sugar of "thirds," or molasses. Indeed the quantity of molasses made by the Alvarado factory is quite insignificant.

Placing the yield in beets per acre at 15 tons, the lowest average, it is found that the total yield of sugar per acre is $190 \times 15 = 2,850$ pounds. The actual yield, however, in all except a few poorly cultivated fields, has been nearly 4,000 pounds, or 2 tons per acre.

Later in the season, *i. e.*, during late winter and early spring, the content of sucrose in the beets will slowly decrease, and by May 1 it is

expected that it will be so low that the further manufacture of sugar will not be profitable. But even by that time the company will have still several thousand tons of beets on hand, on which it now seems probable they will suffer financial loss.

This excess of beets came about in this way: In former seasons the difficulty has been to get the farmers interested in beet-raising to grow enough to secure a liberal supply. The company, therefore, had urged farmers to plant, and agreed to take all the beets offered at a stipulated price.

During the campaign of 1883-'84 the farmers clearly saw that beet-raising was far more profitable than the culture of wheat or any of the usual crops. They therefore gave much more land and labor to beet-culture for the campaign of 1884-'85 than they had ever done before. The result has already been stated.

In a letter dated January 31, 1885, Mr. Dyer says:

Our total receipts of beets this campaign were 20,358 tons (2,000 lbs.). The total amount of refined sugar manufactured and sold this campaign to date is 1,819,266 pounds.

Under date of March 9, 1885, he writes:

We have beets to last through April. They keep well, and still show a co-efficient of purity of over 75.

If the yield continues, as expected, through April, the total output of refined sugar will exceed 3,000,000 pounds.

The study of the preceding tables is a most encouraging one for the farmers. These soils are easily cultivated. In no case was any fertilizer employed, and yet the yield and quality of the roots are fully up to the standard of the forced and expensive cultivation of Germany.

Although the price of labor in California is so much greater than in Germany, I doubt very much whether the cost of the beets per ton is greater. The largest item of expense to the beet farmer in these valleys of the coast range is rent. As much as \$20 per acre is paid annually for beet lands.

Lands of equal fertility and adaptation for beets farther from San Francisco could doubtless be obtained on better terms.

YIELD PER ACRE.

The large differences in yield per acre shown in the preceding tables are not so much due to variation in the fertility of the soil as to methods of cultivation.

The experience of six years has shown that the average yield of beets per acre has steadily increased, and this increase has been due to improved agriculture alone.

At first the farmers (the company does not grow beets) were largely ignorant of the correct method of beet culture, and as this ignorance disappears the results are seen in an increase of the crops.

The factory at Alameda has lately been reorganized and supplied with new machinery. It is now known as the Alameda Sugar Company, and its operations during the past season are given in a letter from the president of the company published in another place.

[From the Rural Californian, October, 1889.]

SUGAR-BEET CULTURE IN SOUTHERN CALIFORNIA.—THE NADEAU EXPERIMENT.—THE CHINO AND SANTA ANA BEETS.—CLIMATIC CONDITIONS.—VILMORIN ON THE SUGAR BEET.—ARE WE TO HAVE SUGAR FACTORIES?

“The culture of the sugar beet in southern California has been in fits and starts, rather than a steady undertaking like the growing of other crops. That the beet will do well in our soil and climate has long since been demonstrated, and its sugar-bearing qualities being above those of the European growth, has always made its extensive propagation desirable, and a very interesting subject from a commercial point of view. The principal objection to its extensive cultivation has been the want of a market to enable the grower to dispose of his product at a remunerative price. This can only be created by the investment of capital in buildings and machinery to convert the raw material into merchantable sugar. Owing to this difficulty our farmers have not taken the active interest in the sugar beet that they undoubtedly would if they had the assurance of a good market. On the other hand, capital has also been shy in seeking investments in sugar factories, not knowing for a certainty that a sufficient quantity of beets would be grown in convenient proximity to the factory, or within easy access by rail, to warrant the construction of immense buildings and machinery for this purpose. The experiments that have been made are for the most part very satisfactory, and clearly show that by proper cultivation, and planting only the best varieties, our soil and climate will yield a beet giving a large per cent. of saccharine matter. When once demonstrated that a large area of our land is adapted to the sugar beet, and our farmers will take a live interest in its culture, capital will be found ready to invest in the necessary buildings and machinery for purposes of refining.

“In this connection it will be of interest to refer to the experience of the late Mr. Nadeau. In 1880 he planted about 700 acres to sugar beets, with the intention, if we recollect correctly, of erecting a factory of his own to convert them into sugar. Be this as it may, he did raise an immense quantity, which on analysis demonstrated that in sugar-producing qualities they were up to if not above the standard of beets grown in Germany and France. The following correspondence gives the results of two analyses, one by Professor Hilgard, of the State University, and the other by Mr. Kulburg, chemist of the Standard Sugar Company, Alvarado:

ALVARADO, CAL., November 1, 1886.

DEAR SIR: The 20th day of September we received about 50 tons of dried beets from Mr. R. Nadeau, of Los Angeles, to be manufactured into sugar. As we were running on our own beets at the time we could not stop to work the whole 50 tons, but manu-

factured about 8 tons into a fair quality of sugar, sufficient to thoroughly test the feasibility of making sugar from sun-dried beets.

Mr. Nadeau sent us at the time some green beets. By polarization they gave about the same result as the dried beets. We made two polarizations with the following results, both taken from two different fields:

Sacchrometer	19.0	Sacchrometer	20.0
Polariscope	11.9	Polariscope	12.8
Difference	7.1	Difference	7.2
Quotient	62.62	Quotient	64.0

These beets were worked and the polarizations were made by Mr. Wm. Kulburg, who has charge of the technical department of our sugar works, and who has had experience in working dried beets in Europe.

* * * We have procured from Mr. Nadeau samples of his fresh beets, as well as those dried by him, and take the liberty to forward the same to you to enable you to make a further test from reliable samples. The samples of beets are somewhat wilted and dried in consequence of having been so long in reaching this place, consequently will polarize more than if taken fresh from the ground. I give the result of Mr. Kulburg's polarization, carefully made by him, October 30, 1880:

Saccharine	16.5	Saccharine	18.5	Saccharine	17.0
Polariscope	11.5	Polariscope	13.6	Polariscope	13.2
Difference	5.2	Difference	4.9	Difference	5.8
Quotient	68.0	Quotient	73.50	Quotient	65.6

Hoping you will favor us with an early reply, we remain,

Respectfully yours,

STANDARD SUGAR MANUFACTURING COMPANY,
By E. H. DYER,
General Superintendent.

E. W. HILGARD,
Professor of Agriculture, State University, Berkeley.

UNIVERSITY OF CALIFORNIA, COLLEGE OF AGRICULTURE,
Berkeley, November 6, 1880.

DEAR SIR: Yours of the 1st inst., with packages of fresh and dried beets, duly received.

The dried beets are now in process of analysis. The fresh beets were polarized immediately after receipt. The results agree substantially with those obtained by Mr. Kulburg, viz.:

Saccharine	17.1	Saccharine	17.2
Polarization	12.8	Polarization	12.3
Purity co-efficient	74.9	Purity co-efficient	71.5

Except in a higher purity co-efficient as an average, but that can easily happen. Except as to the same point, your polarization of beets taken from two fields as given on page 2 of your letter, also agrees; that is, all show a sugar percentage above 12, averaging about 42.5 in the juice. Now, since the juice constitutes about 95 per cent. of the fresh beet, this would correspond to a little less than 12 per cent. of sugar in the green beet; and this, at the rate of four to one, accepted by you, would make up about 48 per cent. in the absolutely free beets, or 43.2 in those containing 10 per cent. of moisture. A determination of the sugar in a sample of dried beets furnished me by Mr. Nadeau, gives 42.1 per cent. of sugar, corroborating, as nearly as possible, the polarizations made and the assumptions of the proportion of four of fresh beets to one of dry. I am at a loss to understand the statement apparently made on page 1 of your letter that the polarization on page 2 agrees with the assumption of 20 per cent. of sugar in the dried beets at the rate of four to one. On its face it gives it fully

double, or over 40 per cent. Please revise and explain your position on this point. I remark that the dried sample sent by you is much more moist and to the taste much less sweet than the samples furnished by Mr. Nadeau. I am, of course, unable to determine which samples represents the fifty tons most correctly.

Very respectfully,

E. W. HILGARD.

E. H. DYER, Esq.,

Superintendent Standard Sugar Manufacturing Company, Alvarado.

"The facts are substantially as follows: Mr. R. Nadeau had about 700 acres of sugar-beets grown. The samples of green beets grown here upon comparison with the standard sugar-beet of Germany, show that those grown in this county are fully up to the standard. The exhibit of beets made by this gentleman at the horticultural fair in October was exceedingly fine, and from the judgment of non-professionals they were considered first-class for sugar-making purposes.

"There were several other letters passed between Professor Hilgard and the Standard Sugar Company, the tenor of which, on the part of the former, seemed to intimate that the Nadeau beets had not been fairly dealt with by the latter. Unsatisfactory, in so far as pertained to the manufacture of sugar, as this initial experiment proved to be, it clearly showed that with the crude appliances used by the Standard Sugar Company, according to Mr. Dyer, only 12 per cent. of sugar was obtained from these beets. The late improvements in machinery make it not improbable to increase the per cent. of sugar from these same beets to 17 and 18 per cent., and possibly still more.

"Owing to other investments and business cares the building of a sugar-beet factory was abandoned, Mr. Nadeau sun-dried his beets and fed them to his stock. This has been the largest experimental effort that has ever been made in Southern California to grow sugar-beets, and proved that in our soil and climate it luxuriates as nowhere else. These beets were grown within a few miles south of Los Angeles, on a sandy loam soil.

"From that time to the present the cultivation of this crop has more or less occupied the attention of our farmers and business men, but no systematic effort has been made to prove the adaptability of large areas of our lands to the cultivation of the sugar-beet as an article of commerce.

"Recently, however, sugar-beet cultivation has again been agitated owing to the fact that it is reported that the corporation of which the Spreckles are the leading spirits is contemplating building a series of sugar-beet factories in various portions of the State, and asking farmers to experiment growing beets in their respective localities. As a prerequisite for the erection of a factory in any locality, Mr. Claus Spreckles writes to the State Board of Agriculture:

Before erecting a factory anywhere I must be guarantied that at least two thousand five hundred acres will be planted in beets each year for a definite number of years. I must also be assured of sufficient supplies of wood, water, and lime in the neighborhood and good transportation facilities.

"The Los Angeles Chamber of Commerce sought to stimulate the interest in sugar-beets, and distributed some fifty packages of seed among the farmers of this county, hoping, by excellent returns to induce a sugar factory to locate here. Somehow, the experiment did not "pan." The recipients of seed paid very little attention to properly seedling and cultivating, and the result on the whole was very unsatisfactory. The few samples submitted to the chamber for analysis in July did not quite reach the standard, though it is conceded that under proper cultivation much better results could have been obtained. The best beets submitted were grown in the Cahuenga Pass, giving a very encouraging percentage of saccharine matter. Farmers in this favored locality are confident that it will grow a fine quality of beet, and are going to keep on experimenting.

"The results obtained from plantings made in last February and March on the Chino ranch, San Bernardino County, are more encouraging. The following, giving the particulars of the analysis of beets grown on the Chino ranch is taken from the Chino Champion :

Mr. J. G. Oxnard, of the American Sugar Refinery in San Francisco, spent part of Tuesday on the Chino ranch. In company with Mr. D. McCarty, he inspected several patches of sugar-beets and made tests of a few samples with satisfactory results. Among the tests made was one from J. E. Bettler's third planting of French seed on April 23, which gave 15 per cent. cane sugar and $83\frac{1}{2}$ purity. By the way, the results thus far obtained are favorable to the French rather than to the German. Mr. Oxnard inspected beets grown by Messrs. Lawrence, Karcher, Bettler, Mrs. Rice, and others. In the case of the Lawrence beets the samples were taken from the outside and inside rows, which was not quite just, as it is well known that outside rows run low in sugar, and yet the result was 14 per cent. cane sugar.

Mr. Oxnard did not hesitate to say that he had never seen better beets, that he was well pleased with general shape and cork-screw form of growth, and also of the quality.

This much can now be stated with absolute certainty : The Chino damp and dry lands will grow sugar-beets, in fact have grown them, to the satisfaction of expert manufacturers ; that in several cases the land upon which the experiments have been made has been cultivated but one year and none of it more than two, and experience proves that the first year land is cultivated the best results are rarely obtained. In some instances where the per cent. of sugar and purity are above the standard the seed was planted and the beets left to grow their own way except that the weeds were kept down, and in but few cases were they given the care required to insure the best quality of beet. To sum up there is not a single element lacking here for a successful beet-sugar manufactory.

"Tests made by different parties and at different times varied in some particulars. The sanguine report that some of the product goes as high as 20 per cent. of sugar, but it is safe to say that the average will be about 17 per cent. Though, according to The Champion, "the trusted chemist," to quote its own words, "of the Messrs. Spreckles has analyzed Chino beets and reports that they contained 19.33 crystallizable sugar with a co-efficient of 86.5 purity,—both far above the average in the most favored beet districts of Europe or America. Beet seed planted on the Chino dry land in May in but a single row and other unfavorable

conditions produced beets that gave 14 per cent. of cane sugar." The beets will go about 18 tons to the acre on Chino lands under favorable conditions, valued at \$5.04 per ton (which was the average price at Watsonville for last year) the crop will prove very profitable, and greatly enhance the value of the land. Mr. Gird, the owner of the Chino ranch, is deeply interested in the subject, and other capitalists, notably the Oxnard Brothers and the Spreckles, are interested in the subject with a view to establishing a factory at this point. Indeed, it is said that the former have an option to put up the works, and investigations are now going on. The factory, if built, will give employment to a large number of hands, and use large quantities of beets during the beet season, necessitating an area of about 3,000 acres planted to sugar-beets.

"Our enterprising neighbors at Santa Ana have also been trying their hand. While there has been no attempt at growing sugar-beets on an extensive scale, the farmers of this favored region seem to be alive to the importance of this new industry, and they are ably seconded by the enterprising business men of Santa Ana. The board of trade has taken hold of the matter, and we look for substantial encouragement from this quarter. The analysis of beets sent some time ago to the sugar factory at Watsonville is as follows:

	No. of beets in sample.	Average weight in ounces.	Total solids.	Polariza- tion.	Not sugar.	Co-effi- cient of purity.
Pet Greenwald	1	17 $\frac{3}{4}$	17.40	12.75	4.65	73.2
G. M. Doyle	3	24 $\frac{3}{8}$	20.50	17.01	3.49	82.9
D. G. McClay	2	54	16.00	8.89	7.11	55.6
John Hassheider	2	21 $\frac{1}{2}$	13.20	8.80	4.40	66.6
D. Edson Smith	2	13 $\frac{3}{8}$	19.60	14.90	4.50	76.8
J. D. Colburn	2	36 $\frac{1}{2}$	12.50	7.22	5.28	57.0
James H. Bett	2	23 $\frac{7}{8}$	16.45	10.77	5.68	65.4
A. Melchert	2	17 $\frac{3}{4}$	19.00	15.15	4.85	74.5
F. A. Marks	1	30 $\frac{3}{4}$	12.60	8.30	4.50	66.0
Do	1	54 $\frac{1}{2}$	12.90	7.75	5.15	60.0
A. Bacon	3	8 $\frac{3}{8}$	16.10	11.80	4.29	73.3
O. W. Bill	2	42 $\frac{1}{2}$	15.50	10.58	5.02	68.3
— Hill	2	30 $\frac{1}{4}$	16.25	12.06	4.19	74.2

"The above demonstrates that the Santa Ana Valley is adapted to this plant. Though the analysis was below that of the Chino beet, yet it was very encouraging, and warrants future development. The business interests of the valley are using every legitimate means to foster and encourage beet cultivation.

"Since the foregoing there has been another analysis made showing a higher per cent. of saccharine matter that is very encouraging.

"Experiments have also been made in other portions of Southern California, all tending to show that the beet can be grown here and that it finds a congenial home in our climate."

EXPERIMENTS AT WATSONVILLE.

The Western Beet Sugar Factory at Watsonville has been in operation two years and apparently with favorable results. The officers of the company kindly furnished the Department with data respecting the season of 1888-'89, an abstract of which follows. A request from us for similar data for the season of 1889-'90 has not been complied with.

Recapitulation of the workings of the Western Beet Sugar Company's factory at Watsonville, Santa Cruz County, Cal., for the campaign ending December 19, 1888.

Sugar, freight from Watsonville to San Francisco.....	\$2,936.55
Coal.....total cost..	17,267.00
Coke.....do.....	1,658.93
Fuel oil.....do.....	11,356.02
Wood.....do.....	990.50
Lime rock.....do.....	1,780.30
Sugar bags.....do.....	1,740.34
Soda.....do.....	12.39
Tallow.....do.....	57.21
Expense, labor, etc.....	21,091.27
(Beets) incidentals.....per pound.....	2,575.82
Cost of beets.....	71,055.89
	132,522.22

Which is the cost of manufacturing 1,640 tons sugar delivered free on board in San Francisco.

We have received for 3,280,000 pounds sugar.....162,454.70

Making cost of sugar \$80.80 per ton of 2,000 pounds.

Profit.....29,932.48

Beets consumed.....tons..	14,077
Sugar produced.....do.....	1,640
Men employed.....	135
Time of run.....days..	61
Beets, average polarization.....per cent..	14.60
Beets, average sugar recovered.....do.....	11.65
Sugar, average polarization.....do.....	95.40
Sugar, average price.....per pound..	5.64 cents
Beets, average price.....per ton..	\$5.04

Manufacturing work at Alvarado.

No report has been received of the operations of the factory at Alvarado during the past season, and therefore I am not able to say whether or not the work was successfully conducted.

MISCELLANEOUS EXPERIMENTS AT THE DEPARTMENT.

Samples of beets were sent from various localities to the Department for analysis during the autumn of 1889. These beets were grown usually by persons who had no knowledge of the proper methods of agriculture

as applied to the production of a beet rich in sugar, and hence it is not at all remarkable that many of them show a low content of sucrose. It must further be considered that the seeds were not in all cases of guaranteed purity, and this would naturally lead to the production of many beets of low sugar content. On the contrary, the exceptionally high percentage of sucrose found in some samples shows very conclusively that there are many parts of this country where sugar beets of the highest grade can be produced. In the case of No. 6562 there is a phenomenally high percentage of sucrose, which probably was due to some adventitious circumstances with which we were not made acquainted. The table of analyses gives the percentage of juice expressed, the percentage of solids determined by actual drying, the percentage of sucrose in the juice, and the purity co-efficient. The samples are described as follows:

No.	From—	Variety.
6523	Ira Ford, Hastings, Nebr	Vilmorin.
6524	do	Not given.
6525	do	Do.
6527	Gustav Onker, Chapin, Ill	Do.
6528	do	Do.
6529	do	Do.
6530	Frank Burnham, Chapin, Ill	Do.
6531	Ira Ford, Hastings, Nebr	Do.
6532	do	Lane's Imperial.
6533	The Empire Coal Company, Gilchrist, Ill	Not given.
6534	Rollin Orcutt, Harmony, Nebr	Vilmorin.
6535	D. Wendhusen, Pender, Nebr	Do.
6536	A. S. Darling, Alliance, Nebr	Lane's Imperial.
6552	Ira Ford, Hastings, Nebr	Do.
6553	do	Do.
6554	do	Vilmorin.
6555	W. C. Euderus, Sturgis, S. Dak	Alkali, white.
6556	do	Sturgis, white.
6557	do	Alkali, red.
6558	do	Bair Butte, white.
6559	John Jenkins, Lincoln, Nebr	Lane's Imperial.
6560	do	Vilmorin.
6561	do	Do.
6562	do	Do.
6563	do	Do.
6564	do	Do.
6565	do	Do.
6566	do	Do.
6567	do	Not given.
6568	do	Vilmorin.
6569	do	Do.
6570	do	Lane's Imperial.
6571	do	Do.
6572	do	Vilmorin.
6610	do	Do.
6611	do	Lane's Imperial.
6612	do	Improved Imperial.
6615	Otto Herbich, Detroit, Mich	Not given.
6616	do	Do.
6617	do	Do.
6620	John Jenkins, Lincoln, Nebr	Lane's Imperial.
6622	R. E. Fleming, Wheatland, N. Dak	Not given.
6640	E. R. Johnson, Brady Island, Nebr	White Vilmorin.
6642	W. A. Anderson, Ord, Nebr	French white sugar beets.

Serial number.	Juice, ex- pressed.	Total solids in the juice.	Sucrose in the juice.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
6523.....	67.52	9.55	5.70	59.69
6524.....	62.65	23.02	9.10	69.89
6525.....	62.02	13.02	9.10	74.50
6527.....	44.66	12.17	8.40	69.02
6528.....	52.94	14.02	9.50	67.76
6529.....	57.79	7.62	4.05	53.14
6530.....	59.54	11.32	7.10	62.72
6531.....	51.50	14.02	9.25	65.90
6532.....	61.83	13.77	9.75	70.80
6533.....	47.14	16.67	13.40	80.38
6534.....	44.65	16.02	12.50	78.02
6535.....	47.55	14.37	9.00	62.63
6536.....	51.83	17.60	12.30	69.88
6552.....	41.71	8.90	6.00	67.41
6553.....	46.95	17.07	12.50	73.22
6554.....	52.85	14.20	10.20	71.80
6555.....	47.95	16.20	10.75	66.35
6556.....	55.11	14.87	8.50	57.16
6557.....	44.11	19.37	13.55	69.95
6558.....	48.44	23.25	17.00	76.40
6559.....	48.23	14.00	9.35	66.78
6560.....	60.56	15.57	10.45	67.11
6561.....	38.31	18.26	13.50	74.17
6562.....	39.04	28.80	22.30	86.43
6563.....	45.39	18.35	13.50	73.56
6564.....	59.44	12.82	10.10	78.77
6565.....	57.74	13.07	9.00	68.85
6566.....	54.63	10.35	6.50	62.99
6567.....		16.20	13.50	83.33
6568.....	48.13	14.52	10.65	74.73
6569.....	55.66	6.92	3.55	51.44
6570.....	55.13	15.37	11.40	74.16
6571.....	46.89	14.65	10.40	70.98
6572.....	46.15	20.27	17.05	84.11
6610.....	45.69	17.48	12.70	72.65
6611.....	53.80	10.37	5.85	56.41
6612.....	45.95	17.30	12.90	74.56
6615.....	55.65	15.52	11.70	75.38
6616.....	54.71	18.05	14.15	78.38
6617.....	47.76	17.97	12.90	71.78
6620.....	48.81	15.20	12.00	78.94
6622.....	43.78	15.27	9.85	64.50
6640.....		23.03	16.40	
6642.....	43.87	22.05	16.45	74.60

BEET-SUGAR INDUSTRY IN CANADA.*

"In order to encourage the beet-sugar industry in Canada it has been decided by the directors of the factories at Faruham to ask of the Government of Quebec a bounty of \$1 per ton for all sugar-beets grown during the year 1890. In order to re-establish the beet-sugar industry at this point the proprietors offer the following inducements in the circular sent to farmers: The seed for planting the beets will be furnished gratis to cultivators; \$4.50 per ton of 2,000 pounds will be paid for beets on board cars; the payment will be made on the delivery of each car-load of beets as soon as they are weighed; an advance of \$10 per arpent will be made in the month of June to cultivators who have at least 3 arpents in beets; a second advance of \$10 per arpent will be made in the month of July to all cultivators who, having properly thinned and hoed their beets, will have at least 25,000 plants left per arpent. Two premiums of \$50 and \$100 will be given for the best 3 arpents of beets."

*Journal des Fabricants de Sucre, March 19, 1890.

FACTORIES IN CANADA.*

"Of the three beet-sugar factories in the Province of Quebec only one worked this year. For various reasons the profits were not satisfactory. The success of this industry is possible, and the manufacture of sugar from beets will in time come to be considered the most remunerative of the country.

"The failures are due to two causes: First, bad management; second, want of working capital.

"The writer (Mr. Mussy) intends to renew his efforts, with French capital, and rent and work the Farnham factory. It is without doubt demonstrated that it is not possible to raise and deliver beets at the factory for less than \$5 per ton. Each of the factories, Berthier and Farnham, has a working capacity of 15,000 tons. The writer suggests that American capitalists secure these factories where the farmers are already educated in beet-raising, in preference to building new works. These factories are located only a few hours from Boston and New York.

"The writer further states that in the vicinity of these factories many farmers are growing sugar-beets for their cattle. The Berthier factory worked this year. From an agricultural standpoint the campaign has been a great success, beets were purchased at \$4 per ton and farmers were willing to contract for almost unlimited areas for next year. Unfortunately only 30 tons of roots have been worked per diem, while the capacity is 200 tons, and during the campaign of 1882 there was an average of 150 to 170 tons utilized per twenty-four hours."

THE BEET SUGAR INDUSTRY IN ENGLAND.

Dr. Schack-Sommer† contributes a paper setting forth the advantages which would accrue from the introduction of the beet-sugar industry into England. Four varieties of beets were grown by him from seeds obtained from Dr. Scheibler. The four varieties grown were:

1. Dippe's Richest Sugar-beet.
2. Dippe's Improved.
3. Dippe's Improved Red-headed.
4. Dippe's Improved Klein Wanzlebhen.

The fertilizer recommended for the beets is 200 to 300 pounds of nitrate of soda and from 400 to 600 pounds of superphosphate per acre. It is recommended to plow the soil 14 to 15 inches deep.

Experiments were made at two localities, one on the farm of Mr. John Ennis in Springwood, Ireland, and the other on the farm of Mr. John Gibbons in Wavertree, near Liverpool. An analysis of beets made on

*Abstract of a letter to the editor of the Sugar Beet, from A. Mussy. From "The Sugar Cane," February 1, 1890.

†Journal of the Society of Chemical Industry, February 28, 1890.

the 26th of September at the two stations, showed at the English station the following percentages of sugar: 15, 15.6, 14.7, 14.2; and at the Irish station, 16.7, 17, 18.2, 16.8. On the 10th of October another set of analyses was made at the two stations with the following results: At the English station, the percentages were 16.5, 17, 16.7, 16.4, and at the Irish station 18.2, 17.5, 17.2, 18.8.

The apparatus invented by Meyer and Buettner for drying the sliced beets is also described and it is claimed that with this apparatus it is possible to dry 225,000 kilograms of sliced beets per day at a cost of 8 cents per 100 pounds. In regard to the quantity obtained per acre at the English station the yield was 42 tons and 19 cwt.

BEET SUGAR IN THE NORTHWEST.

POINTS FOR CONSIDERATION WITH REGARD TO THE INTRODUCTION OF THE SUGAR-BEET AND THE MANUFACTURE OF BEET-SUGAR IN THE NORTHWEST AS COMPARED WITH THE BEET-SUGAR PRODUCING COUNTRIES OF EUROPE, BY J. D. FREDERICKSEN.*

"1. *Climate*.—In Europe the northern part of the temperate zone affords the most favorable conditions for the growth of the sugar-beet and the development of a pure juice from which the sugar is easily extracted. The northern part of Germany, Prussian Saxony, Brunswick, and Hanover; Denmark and the southern and middle sections of Sweden; Belgium, Holland, the northern departments of France; Bohemia and a section in the middle of Russia, all produce beets from which sugar can profitably be manufactured. Sections with complete inland climate seem to produce richer sugar-beets than those with coast climate. In northern Germany and certain parts of Russia and Sweden the beet is generally richer in sugar than in France, Belgium, Holland, or Denmark, the latter countries being more exposed to the sea. In England, where the climate is moist and temperate all the year round, the beets grow bulky but poor in sugar, and there the beet-sugar industry has proved a complete failure.

"As to Denmark the climate is not so favorable to the development of sugar in the beets as it might be. The spring is rather dry, so that it is hard to get the plants started, and the fall is so wet that there is a danger for the beets to set flesh at the expense of the quality of the juice. For the same reason the harvest is difficult. Still the industry is flourishing, so that the climate may not be called bad.

* McMurtrie, *op. cit.* pp. 275, *et seq.*

“The following table shows the average temperature and rain-fall at Copenhagen, in Denmark, and in Minnesota :

Months.	Minnesota.		Denmark.	
	Tempera- ture.	Rain.	Tempera- ture (82 years).	Rain (44 years).
	Fahr.	Inches.	Fahr.	Inches.
January	15.85	.49	29.84	1.74
February	14.40	1.07	30.92	1.52
March	23.66	2.24	33.80	1.56
April	37.52	.95	42.08	1.46
May	62.24	1.65	51.62	1.49
June	68.70	11.67	59.90	2.12
July	74.72	1.94	63.14	2.30
August	70.54	3.90	62.24	2.48
September	60.95	5.76	56.12	2.18
October	49.36	3.21	47.84	2.17
November	28.72	1.90	38.84	2.04
December	18.81	.72	33.80	1.69
Total	43.62	35.50	45.84	22.75

“Comparing these figures, it would suggest itself that the excessive rain-fall in Minnesota in June might favor the development of the young beets, but at the same time make it very troublesome to perform the work of harrowing and hoeing to keep the land clean from weeds. The months of August, September, and October also seem rather moist, making it possible that too much inorganic matter may enter the juice at the time when the beets get ripe. Still, when falling in heavy showers at long intervals, as it probably does in Minnesota, the rain is neither likely to influence the beets nor to bother the harvest in the same way as when coming down gradually at short intervals. More water will evaporate from the soil, and therefore more rain is needed in Minnesota than in Denmark on account of the higher temperature of the former. According to another account the fall of rain in Minnesota is as follows:

Seasons.	Minne- apolis.	Duluth.	Breckin- ridge.	Pembina.	New Ulm.
Winter	3.105	2.160	4.980	2.750	2.260
Spring	7.960	6.480	6.250	2.450	6.300
Summer	16.304	20.850	14.150	7.250	7.020
Fall	5.108	8.060	3.580	6.910	9.280
Annual	32.456	37.556	28.960	19.360	24.860

“With such extraordinary differences within the same State it would seem likely that some sections, at least, may be favored with the proper climate for a successful cultivation of the sugar-beet. The temperature of the summer does not seem excessively high, for even far south on the continent of Europe the beet is grown successfully, and just in those of the above sections where the beets are richest in sugar the summer heat is comparatively high.

"2. *Soil*.—The proper soil for the sugar-beet is neither too heavy (clayish) nor too light (sand), nor containing too much organic matter. A well cultivated, rich, and deep soil, that would produce a good crop of barley for malt, is well adapted for the sugar-beet. New and rich land, that in a crop of cereals would develop the straw at the expense of the seed, would make a bulky crop of beets, but they would be poor in sugar and rich in non-sugar, detrimental to the extraction of the former from the juice. Land of old cultivation, made rich by continued plowing and manuring, is better than newly broken land. Therefore, without knowing from personal experience, one would imagine the soil of Illinois to be better adapted to the sugar-beet than that of Minnesota. The land should be well drained, either by nature or by pipes laid deep in the ground, allowing no water to remain on the surface at any time.

"The limits for the physical condition of the soil are, however, very wide, for we have grown rich sugar-beets on comparatively heavy and on comparatively light soil, the former being made porous by deep drainage and intense stirring with steam-plow and cultivator. But, whether heavy or light, only land in a state of high cultivation could produce beets rich in sugar.

"3. *Labor*.—One of the worst drawbacks to the successful introduction of the sugar beet in the northwest would seem to be the labor question. Even with the advantage of the best implements to stir the land, thin and clean the ridges, and gather the crop, the hand-labor needed to grow sugar-beets is considerable. Wages being about three times as high in the northwest as in Denmark, this would increase the expenses at a great rate. Supposing one hand to be needed for 3 acres of land for four months, about thirty days' work would be necessary to cultivate 1 acre. Supposing 1 acre to yield 15 tons of beets or 2,400 pounds of sugar (8 per cent.), thirty days' work, at \$1.50 a day, would make \$45 an acre, or \$3 per ton of beets, or 18 $\frac{3}{4}$ cents per hundred-weight of sugar, while in Denmark, at 50 cents a day, the labor would only amount to one-third of these expenses. And supposing the product could bear such expenses, would it be possible to gather a sufficient number of hands so as to grow 1,500 acres of beets within the limit for the area of one sugar factory? For it is a deplorable fact that, at the present development of the industry, sugar can not be manufactured from beets on a small scale, but must be produced in large establishments, which require the raw material from a large number of acres. And, on account of the bulky quality of the beets, they can not bear long transportation, and must therefore be grown within a certain comparatively narrow distance from the factory. Again, during the manufacturing season, which only lasts about four or five months, the factory would employ a number of hands who, after all of the beets have been disposed of, would have to look for employment elsewhere. While at the time between the clearing of the beet land and the harvesting of

the beets the regular harvest of the cereals might give employment to the beet hands, would the forests of Minnesota or other industry dispose of the laboring hands during winter and early spring, until the beet field again might need them? Sugar beets should not be attended to only when the other work of the farm is done and there is nothing else to do, but should be worked when they need working. Without independent labor at the proper time their cultivation always proves a failure. So also should the manufacture of sugar begin when the beets are ripe and contain most sugar, and it should be continued energetically as long as any beets are left, in order to dispose of the whole crop before too much sugar is lost, for every day after the beets are ripe they grow poorer in sugar. Therefore laboring hands must be at disposal at any time when they are wanted, independent of other work that might need them.

"In the factory the high rate of labor in the the Northwest would add considerably to the expenses; while in the beet field where, in Denmark, female hands are employed in a great measure, the labor would probably be three times higher in Minnesota than in the old country, the manufacturing labor expenses would, no doubt, be twice as high in Minnesota as in Denmark. In the latter country the labor expenses in the factory amount to \$1.15 per ton of beets, or about .72 cent per pound of sugar.

"4. *Other expenses.*—Quite different is the case with regard to other expenses than laboring. The cheapness of the land in the Northwest as compared with rich land in the old country will, no doubt, do much towards reducing the expenses of the growing of beets in Minnesota. In Denmark the rent for rich land amounts to \$7 to \$8 an acre. In Germany as much as \$16 per acre is paid yearly for a rentage lasting ten or twenty years. In the Northwest, improved land could probably be had for less than half the rent in Denmark.

"In the factory coal plays a prominent part among the expenses other than labor. In Denmark this item amounts to \$1.20 per ton of beets or .75 cent per pound of sugar—the price for coal being \$6 per ton. This price being reduced to \$2 per ton, the expense for fuel would be 40 cents per ton of beets or .25 cent per pound of sugar only.

"5. *Duty.*—In the old country the duty paid to the government by the manufacturers makes a heavy reduction of the profit realized by the production. In Germany the duty is laid on the beets, being raised gradually from 1836, when it was only one fourth silver groschen per hundred weight (11 cents per ton) of beets, to the present time, when it amounts to 9 silver groschen per 100 pounds (\$4 per ton). This is, in a great measure, the reason why in Germany the manufacture of beet sugar is developed to such admirable perfection as is the case. The more sugar that could be gained from the beets, the less the duty drew on the profit of the manufacturer, for the duty on 1 ton of beets remained the same whether 6 or 10 per cent. of sugar were extracted.

All the efforts of the farmer and the manufacturer had the aim to produce much sugar from a certain weight of beets, not to produce much sugar from an acre of land. Therefore the quantitative yield of beets was neglected, while beets were produced which yielded as much as 10 per cent. of sugar.

"In Sweden the same system is adopted. In Belgium and partly in Holland the duty is calculated on the basis of the quantity and richness of the juice extracted from the beets. In France and in Denmark the duty is laid on the sugar produced. For this reason it is in these countries the aim of the producer to get the largest yield of sugar from an acre, only provided that it can be profitably extracted. Therefore the yield of beets is larger, but their contents of sugar less than in Germany. In Denmark the duty is equal to that on imported sugar, amounting to 2.16 cents per pound of raw sugar (below No. 18 Dutch standard), or about \$3.45 per ton of beets. The duty in this country being about 3.5 cents for average raw sugar, this item would amount to \$5.60 per ton of beets in favor of the manufacturer, provided 8 per cent. of raw sugar can be extracted (besides the molasses).

Summing up these items the following figures are arrived at in favor or in disfavor of the sugar industry in Minnesota, as compared with Denmark, provided 8 per cent. of sugar is realized in both countries:

	Extra expenses in Minnesota.		Savings in Minnesota.	
	Per ton of beets.	Per pound of sugar.	Per ton of beets.	Per pound of sugar.
Labor in field	\$2. 00	\$0. 0125		
Labor in factory	1. 15	72		
Rent			\$0. 23	\$0. 0014
Fuel			. 80	. 0050
Duty			5. 60	. 0350
	3. 15	197	6. 63	. 0414

"Deducting the extra expenses from the savings, we arrive at the following real savings in favor of Minnesota:

Per ton of beets	\$3. 48
Per pound of sugar	2. 17

"But the whole calculation depends upon the question, can beets be grown in Minnesota which will yield 8 per cent. of sugar? The most careful study of tables of rainfall and temperature, and of analysis of the soil, can not decide the question. The only way is to try. Seed of rich sugar beets should be distributed to intelligent farmers throughout the Northwest, accompanied by directions how to grow beets. The farmers who undertake to carefully make the experiments should be requested to return an average sample of the crop, describing the soil in which the beets are grown, and the treatment of it; the fruits which the land bore in previous years; the manure, if any, that was used;

the time in which the manure and the seed were sown, and at which the thinning out, the harrowings and hoeings, and the harvest were performed; the yield per acre, etc. The samples should be analyzed, not only for sugar (and especially that kind of sugar which would turn the polarized light to the right, and which would crystallize), but also for organic and inorganic non-sugar. Such material for one year would already afford valuable suggestions, and, carried on for several years, such experiments would justify a decided opinion about the propriety of the introduction of the industry. To start a large and expensive factory without such foundation would be to run a great risk, and to establish small and cheap factories would always prove a failure.

"As to the plan for establishing sugar factories, several systems prevail in Europe. One is the co-operative, very much like the system of cheese factories and creameries in certain sections of this country. The farmers in a section intending to establish a sugar factory form a joint stock company, and are bound to deliver to the factory the beet crop of a certain number of acres for each share in their possession in Brunswick generally 8 acres for each share of \$100).

"For the last ten years the sugar factories have become very expensive, being profitable only when very large, and when furnished with the latest inventions. Therefore, the farmers could not afford to build their own factories if it were not for large stock companies which undertake to build and furnish factories for the farmers, leaving the greater part of the cost at low interest to be paid off gradually, against mortgage in the buildings. This plan does not work well in a country where the industry is new, and, though it is no doubt best of all, it can not be introduced until the beet sugar industry has proved an unquestionable success, and is known to the people as a safe thing to invest in.

"Another plan is for a stock company to establish a factory, buying the beets from the farmers, and return the refuse (pulp) to be consumed on the land, so as not to exhaust the latter. It is, however, not an easy task to induce the farmers at once to grow an area with beets large enough to furnish a factory with sufficient raw material of good quality for a successful starting. It takes time and experience to learn how to grow rich sugar-beets; the best way to learn it is to get direct interest in the profit. Therefore such concerns who build factories, intending to buy the beets in a section where the industry is not previously known, are generally forced to grow a large portion of the beets themselves, by establishing some kind of bonanza farms, or by renting suitable land for the purpose, returning it to the farmers after the crop has been gathered. In fact, this is the only way to secure within reasonable time enough of good raw material, until, by and by, the farmers are educated for the task.

"In Denmark the beet-sugar industry was introduced in 1873, when it had been ascertained by experiments during several years that sufficiently rich sugar-beets could be grown. Two factories were started, one by an old concern that previously commanded the whole sugar-refining business of the country, the other by a new stock company prom-

inently made up of landed proprietors. The former company built a large factory in a fertile section occupied by intelligent farmers, who, it was thought, should furnish the beets. The factory was capable of working up 12,500 tons of beets a year. The first year only 2,500 tons of poor beets were received, and the second year proved but little better. Then the managers were convinced of the necessity of adding farming to their business, and bought a farm of 300 acres, to manage which an expert was engaged. Another year more land was added to the farm, and suitable fields were rented for one year and grown with beets by the manufacturers. On these lands rich sugar-beets were grown. In the meantime the farmers learned how to grow the beets, and the quantity received at the factory increased yearly, until now sufficient raw material is furnished so as to run the factory profitably. Large amounts of money were lost during the first five years. The business seemed condemned to failure, but the managers succeeded in keeping it going until the balance turned, and now the factory is flourishing.

"The other company went at once to work and rented for twenty years three large farms, of 2,000 acres of land in all, every acre of which was in a state of high cultivation and well drained. This land was divided into four fields and sown successively with wheat, beets, barley, and clover, so that every fourth year beets were grown on the same land. Steam-plows and first-class machinery were introduced. The factory was built so as to work up 7,500 to 10,000 tons of beets a year. Besides those grown on the 500 acres of the company, more beets were grown by the company on land rented yearly and being returned to the farmers after use, and as many as possible were bought. In this way the company succeeded in gathering 6,000 tons of tolerably rich beets the very first year, sufficient to make a rather successful start. The factory being built at a time when all materials were as expensive as ever; the price of sugar falling about 30 per cent.; hard competition being brought to bear from the sugar refiners; an excessive duty even higher than that on imported sugar* being at once enforced as soon as the manufacture was started; and finally entering the time of universal financial depression, commanding insufficient capital, the company could, however, not carry the work through, and failed in 1876. A new company took the matter in hand, and carrying on the business on the same principle as it was hitherto managed, have succeeded in making it pay well.

"Having passed through extraordinary difficulties, the beet-sugar industry in Denmark is now successful. But though a handsome profit is realized by the manufacturers, it is nothing compared with the indirect profit which is the result of the improvement of the land where

* The duty at once laid on the manufacture of beet sugar in Denmark was a few years later acknowledged by the government to be higher than that on imported sugar, and was reduced accordingly. In no other country in the world has this industry suffered an immediate imposition of duty, time being everywhere else allowed for the industry to develop and acquire stability.

beets have been grown. The influence on the land of the deep and thorough cultivation, and the use of fertilizers, which go hand in hand with the growth of the sugar-beet, of the beet itself by opening and manuring the soil, and of the stable manure which is produced by this system, is simply wonderful. All other crops are increased and their quality improved. On such land as would previously produce only common barley, a highly praised malting grain is now raised, which brings far better price than the old product. Those farmers who at first looked suspiciously on the new industry are now quite enthusiastic in favor of it, and several factories are about to be built this year."

USE AND TREATMENT OF PULPS.

PRESERVATION OF DIFFUSION PULPS IN SILOS.

Instead of feeding the diffusion pulps at once they may be kept in silos for future use. A silo suitable for this purpose is described by Minangoin.* In silos made of earth there is a considerable loss of material on account of mixture of the earth with the pulp. On the other hand, the cost of silos constructed in masonry is very great. The pressure of the pulp is so great that such silos must have an unusual thickness to withstand it. A cheaper form of silo is therefore indispensable for farmers' use.

A silo made of heavy planks appears best suited for preserving the pulp.

The silo described by Minangoin is about 70 feet long and 6 feet wide. The bottom is made of a layer of stone, but without cement. The surface is slightly raised in the center to permit of the outflow of liquid on both sides. A ditch surrounding the silo is disposed in such a manner as to properly dispose of the drainage water. The boards of the silo are supported by oak posts 4 inches square, deeply set in the earth, and placed at distances of about 5 feet apart. These posts are connected from side to side by iron rods one-half inch in diameter.

Between each plank in the sides and ends of the silo is left a space, 1 inch, to facilitate the drainage of the pulps. The planks should have a width of about 1 foot. For convenience in filling, as well as for use, it is well to divide the silo into parts by running a partition from post to post. By leaving out the iron rods until each partition is filled and filling the farther part first the charge may be brought directly into the silo from its open end. The silo should be 5 feet high at the sides and 8 feet in the center, and will then contain over 300 cubic yards of pulp. The pulps are preserved perfectly. The pulp gradually acquires a remarkable dryness and density, and there is no waste either at sides or bottom. It is not necessary to furnish it with a cover.

**Sucrerie Indigène*, March 25, 1890, page 282.

PRESERVATION OF BEET PULP. *

“On well-organized sugar-beet plantations there should be special arrangements for keeping refuse pulp during the winter, a period when green fodder (so essential to the health of live-stock) is difficult to procure.

“In previous issues of *The Sugar Beet* we mentioned experiments made from year to year in pulp preservation, and how this refuse may

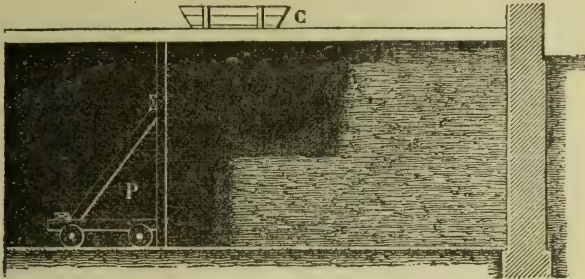


FIG. 44.—Vertical section of silo for beet pulp.

be kept in good condition by a liberal use of salt, etc. The greatest difficulty to contend with is the water retained by the pulp; fermentation soon follows. The organic transformations are not objectionable if

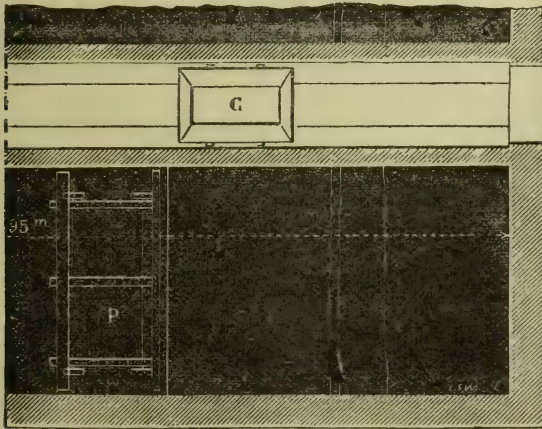


FIG. 45.—Horizontal section of silo for beet pulp.

arrested at the proper moment; on the contrary, live-stock seems to eat with considerable avidity pulp having slightly soured, or of acetic taste.

If the cattle to be fed are numerous, their daily consumption may be equal to the supply; silos under such circumstances are unnecessary. On the other hand, during the one hundred days representing an ordinary campaign of beet-sugar factories, the fattening results can not be satisfactorily obtained, because the period is too limited. From a general point of view pulp silos may be a source of considerable revenue to all interested.

"At the Ferme de la Briche (France) may be seen a silo of 4,000 cubic meters capacity used for distillery pulp. The refuse is carried from mash tubs in cars C, Figs. 44 and 45, in which it is mixed with chopped straw, hay, etc. A movable partition P (19.68 by 11.48 feet), having the exact dimensions of the silo's cross-section, is mounted on wheels and placed a short distance from the end wall. The intervening space is filled with closely-packed pulp, thus preventing fermentation, and a layer of 10 inches earth covers the top. The partition is moved backward, and the foregoing operations repeated. It is said that beet pulp, under such conditions, will keep for years; it is taken from the silo in vertical slices."

DRYING OF THE PULPS FOR PRESERVATION FOR FEEDING PURPOSES.

In an address made at the agricultural association of the Province of Hanover, Mr. Koester described the process of the drying of pulp for the purpose of preserving it for cattle food. This new feeding stuff is known by the name of 'dried diffusion pulp,' and is being largely discussed in France lately. Very little is known in regard to it by the farmers themselves up to the present time. The cost of the drying plant and the expenses of the process are great and there is much doubt whether any profit results from it. Some of the data in regard to the matter have been collected by Mr. Koester. He says if he had received, during the present year, the whole of his pulp in the humid state he would have been compelled to transport 57,000 quintals. Of this quantity 9,000 would have been consumed during the campaign, and 48,000 would have been preserved. If these 48,000 quintals had been dried the expense of placing them in silos, and the transportation of them from the silos to the feeding-stalls, would have been saved. This extra expense is estimated to be from 2.5 to 3 pfennigs per quintal, or, expressed as a mean of the whole cost, 1,330 marks. The drying of 48,000 quintals of pulp would have cost 4,320 marks; deducting from the above the 1,330 marks for the expense of preserving the wet pulp, there would remain a net expense of 3,000 marks for the desiccation. It is estimated that the undried pulp, in keeping, lose in all about one-third of its nutritive value, which would be equivalent to 16,000 quintals. If, however, these 16,000 quintals had been dried they would have yielded 1,880 quintals of dried pulp. It is estimated that the feeding value of 1,880 quintals of dried pulp is equal to 7,500 marks;

deducting from this sum the net expense of desiccating, viz, 3,000 marks, there would have resulted a net gain on the whole mass of 4,500 marks. One factory at Rethen worked up nine times as many beets as were furnished by Mr. Koester; they would, therefore, have realized 40,000 marks profit by drying all of their pulp. The process of drying the pulp employed was that of Buttner and Meyer. The dried pulp furnishes a food which is preserved indefinitely without alteration, provided it is put in a dry place. According to Wolff it contains:

	Per cent.
Water	11.6
Ash	7.1
Crude protein (of which digestible 4.1 per cent.)	6.6
Fiber (of which digestible 16. per cent.)	19.3
Non-nitrogen matters (of which digestible 45.9 per cent.)	54.8
Fats (of which digestible .6 per cent.)	.6

It is therefore a nutriment especially rich in carbohydrates, but one which should be supplemented by some food furnishing the missing qualities; for instance, some food rich in nitrogen.

It is not necessary to saturate the dried pulp with water before giving it to cattle. Animals consume the pulp willingly in the dried state, and the experiments of Professor Maercker have shown that the nutritive effect is at least as good with all kinds of animals as when fed the moist pulp. Mr. Koester has had equal success in feeding this food to milch cows, to cattle preparing for the market, and to sheep. He has even fed it to calves of four months old, and young lambs, who take it willingly. It has also been given to horses with success, in the proportion of from 5 to 6 pounds for each one. We seem, therefore, to have in this dried pulp a nutriment capable of any application, and which appears destined not only to play a grand role in the alimentation of cattle, but also to render superfluous many other kinds of forage, and to give an opportunity to use to a considerable extent such materials as cotton-seed and linseed cakes rich in nitrogen matter. In the case of five beeves which were fattened, they received, besides straw and moist pulp, a mixture of dried pulp, peanut cakes, sesame cakes, and cotton-seed meal. During four weeks in which the effect was noted, the animals increased at the rate of from 2 to 3 pounds per day.*

FEEDING EXPERIMENTS WITH THE LEAVES AND DIFFUSED PULP OF BEETS.†

At the general meeting of the Central Agricultural Society of the Duchy of Brunswick, February 25, 1890, Professor Maercker gave an address upon certain recent feeding experiments, which were of special interest to the sugar interests, as the experiments treated of the values

*Journal des Fabricants de Sucre, April 9, 1890.

† By Professor Maercker, Halle.

of beet leaves, also of the pulp, after diffusion, both in the moist and dry conditions.

Professor Maerker commenced by stating that the tables of Wolff, which allow 3 pounds of nitrogenous food matter per 2,500 pounds of the living weight of the animal, are no longer to be accepted in view of existing standards of cattle feeding. It is more advantageous to raise the allowance of nitrogenous matters, and gradually, to the relation of 5 pounds per 2,500 pounds of living weight. Contrary to the increasing of the proportion of non-nitrogenous matters, as advised by the Wolff tables, it may be a detriment to the animal system, and, economically, an actual disadvantage.

Experiments were conducted in order to ascertain the approximate value of beet pulp after the act of diffusion. Three classes of experiment animals were fed respectively, with 50, 75, and 100 pounds of diffused pulp, deductions being made in the other foods fed to the animals in proportion to the respective increments of nitrogenous matter contained in the three rations specified. An increase was observed in the volume of milk given by the animals of from 12.6 and 12.7 quarts respectively to 13.2 and 14.2 quarts without any depreciation of the quality of the milk being observed. On the other hand, not any increase in the living weight of the animals had occurred, and in the examples where 100 pounds of the pulp had been served to the cattle an actual diminution of weight had taken place. The maximum quantities of the diffusion pulp which it appears advisable to serve to the different classes of animals are as follows: To cows in milk, 40 pounds; feeding oxen, 90 pounds; and to feeding sheep, 5 pounds. It has been further observed that the distillery residues may be served to cattle in double the quantity of the diffusion pulp providing that the animals receive the former in a warm state. As a result of this observation artificial preparations of potatoes and cotton-seed meal have been made and fed to cattle in the warm state, and with a clear gain of 4 cents per cow per day.

There is one other source of food for cattle which has not received the attention which it deserves: That is the leaves of the beet. At present those materials are merely browsed by sheep on the land where they lie, and the greater part is trodden into the soil. In some instances the leaves are mixed with the diffusion pulp and preserved in silos, or the leaves are preserved in the silo alone. Professor Maerker has made several experiments at Siegersleben for the purpose of determining the food value of the beet leaves and he proposes to continue his experiments during this year.

He gave to ten sheep 125 pounds of beet leaves in the form of ensilage, and to ten other sheep 90 pounds of diffusion pulp, taking care that the other foods given to the animals contained the same amounts of nitrogenous matters. The increase in weight of the ten sheep fed with beet leaves was 3.4 pounds, and of the ten sheep fed on diffusion

pulp, 4.1 pounds, showing an apparent advantage in favor of the latter of 23 per cent. From the stand-point of economy, however, the case was otherwise: The gain of the ten sheep fed on diffusion pulp was 4.6 cents per head, whilst the money value of the increase of the ten sheep fed on the beet leaves was 6.4 cents per head. It is thus seen that the greatest increase in weight may not essentially represent the greatest gain.

In certain other experiments the foods already specified were supplemented with respectively $\frac{1}{3}$ pound of cattle food prepared from poppy seed and 1 pound of rice meal for each ten sheep, when an increase of weight was observed of 4.1 pounds and a gain of 10 cents per head.

In feeding the ten sheep with beet leaves, allowing the animals to consume what they liked, 169 pounds were consumed without damage to health, and yielding an increase of weight of from 4.17 to 4.8 pounds and a money value of from 11 to 14 cents.

In the leaves of the beet there is thus found an excellent article of diet for the feeding of cattle. The leaves may be valued at from 25 to 30 cents per 250 pounds. If it be calculated that one acre will yield varying from 12,500 to 25,000 pounds, that amount would represent a food value per acre of from \$25 to \$60.

Professor Maerker has also conducted comparative experiments with diffusion pulp in the humid and dry states, respectively, and has found the results to be demonstratively in favor of the latter. The pulp in the dry state contained from 55 to 60 per cent. of non-nitrogenous matter and $6\frac{1}{2}$ to 7 per cent. of nitrogenous matter, 85 per cent. of the latter being digestible, whilst only 75 per cent. of the nitrogenous matter in the humid state becomes digested.

The cost of purchase of the diffusion pulp in the dry state may be calculated as follows:

	Cents.
Average price of 250 pounds of dry pulp.....	12
20 per cent. loss of material in depot	2
Cost of transport	1
Cost of ensilage (preservation)	2
	17

The feeding of cattle with the material in the moist state is not only inconvenient but conducive to certain forms of disease.

The best process for the drying of the pulp is that adopted by Messrs. Büttner and Meyer. These gentlemen have guarantied the cost of drying shall not exceed $2\frac{1}{2}$ cents per 250 pounds of pulp. Hadmersleben has reduced the cost of desiccation to 2 cents, and expects to reduce it still further to $1\frac{1}{2}$ cents per 250 pounds.

The experiments were carried out as follows: On the one hand the moist pulp was fed to the cattle with hay or grass and a good portion

of the cattle cake. On the other hand the animals received the dry pulp and a portion of cattle cake less rich in nitrogen. It has been established that the quantity of milk obtained was on the average the same from the dry as from the moist pulp, and the cost of feeding with the dry pulp was 2 cents per head per day less with the dry than with the moist pulp. In taking all the conditions into account it is estimated that the advantage in feeding cattle with dry pulp over the moist is on an average about \$14 per head. About 20 pounds of the dry pulp is equal to 130 pounds in the moist state.

The cultivators should endeavor to get the sugar manufacturers to commence the system of desiccating the pulp, either alone or in agreement with the cultivators, in order that a large proportion of that feeding material which at present is allowed to waste may be wholly utilized in the feeding of cattle.

MANUFACTURE OF SUGAR.

The process of the manufacture of sugar from the sugar-beet is one which interests the agriculturist only from secondary considerations and for this reason will be treated of in this bulletin in the briefest possible manner to give an intelligent idea of its methods. The process of manufacture is no longer an experiment but a positive method, from which, with beets of a given richness, a definite output of sugar can be calculated.

The beets, having been properly harvested and delivered to the factory, the general process of manufacture is as follows:

The beets are first conveyed to washing-tanks provided with suitable apparatus for keeping them in motion and transferring them toward the end from which the fresh water enters, in order that the whole of the adhering soil, together with any sand and pebbles, may be completely removed. By a suitable elevator, the beets are next taken to a point above the center of the battery, whence they are dropped into a slicing apparatus. This apparatus is provided with knives with serrated edges, by which the beets are sliced into pieces of greater or less length and of small thickness, so that when placed in the cells of the battery they will not lie so closely together as to prevent the circulation of the diffusion juices. The slices, commonly called cosettes, next pass into the diffusion battery in which the sugar is extracted in the usual way. The extracted cosettes are carried through a press by which a portion of the water is removed, and they are then in suitable condition for use as cattle food. The diffusion juices are carried to carbonatation or saturation tanks, where they are treated with from 2 to 3 per cent. of their weight of lime and afterward with carbonic acid until nearly all of the lime is precipitated. The slightly alkaline juices are next passed through filter presses by which the precipitated

lime and other matter are removed. The juices pass next to a second set of carbonatation tanks in which they undergo a treatment in each particular similar to the one just mentioned, except that the quantity of lime added to the second saturation is very small as compared with that of the first. The refiltered juices from the second saturation are carried to the multiple effect vacuum-pan and reduced to the condition of sirup. The sirups are taken into the vacuum strike pan and reduced to sugar called *masse cuite*, containing from 6 to 10 per cent. of water. The uncrystallized sirups together with the water are separated from the sugar by the centrifugals, and form the molasses. The molasses is either reboiled and a second crop of crystals obtained, or is treated in various ways for separating the sugar which it still contains. One of these methods which has come into general use is known as the Steffen process, and is described in detail further on. Another method consists in separating the salts which prevent the crystallization of the sugar by the process of osmosis. A third method consists in the use of strontium salts for the separation instead of lime salts as in the Steffen process; or, finally, the molasses may be subjected to fermentation and distillation and the sugar therein contained thus converted into alcohol.

The above is the general method used for the manufacture of raw sugar. If refined sugar is to be made the juices and sirups are passed over bone-black to decolorize them and the crystals are washed in the centrifugal in order to make them perfectly white. Another method of purifying the crystals consists in washing them with sirups of varying degrees of consistency until all the molasses adhering thereto is washed away. For the details of the various processes with the exception of the Steffen process, which is given further on, standard works on beet-sugar manufacture may be consulted.

The following observations on the manufacture of beet sugar are taken from Mr. Spencer's report in Bulletin No. 5, of the Chemical Division, Department of Agriculture, pages 107, *et seq.*

"EXTRACTION OF THE JUICE.

"The most usual method for extracting the juice from the beet is by diffusion. This process has been so successful that now but comparatively few sugar-houses employ presses, either hydraulic or continuous.

"Diffusion batteries may be divided into two classes :

"(1) The ordinary, consisting of a number of cells.

"(2) The continuous, having but one cell. The first may be divided into (1) battery in line, (2) circular battery.

"The ordinary diffusion battery is composed of several cells, usually twelve in number. They are so arranged that as soon as one cell or diffuser is charged with beet cuttings it is closed and warm water forced

into it. The water takes up a portion of the sugar and then enters a second diffuser charged with fresh cuttings or *cossettes*.* This operation is repeated, until the juice from the first diffuser, having passed through a certain number of cells, leaves the last heavily charged with sugar.

"In working a diffusion battery, one diffuser is being charged and a second emptied while the rest of the battery is under pressure.

"The arrangement of a battery, whether in a line, a double line, or a circle, depends quite often upon the space at the disposal of the sugar manufacturer. The circular arrangement requires a higher building

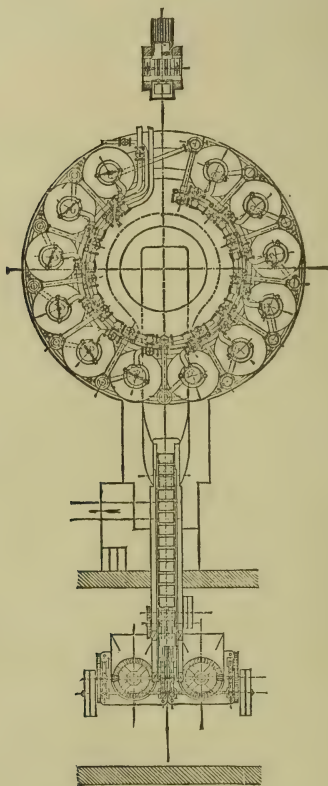


FIG. 46.

owing to the position of the slicing machines, but nevertheless it is usually considered preferable to a line battery. Among the special advantages of a circular battery is the economy of labor. Another advantage, and quite an important one, is that all the diffusers are under the immediate control of the workman in charge. The beet slicer is placed above the battery, a swinging funnel conducting the cossettes

*Cossettes in French, Schnitzel in German.

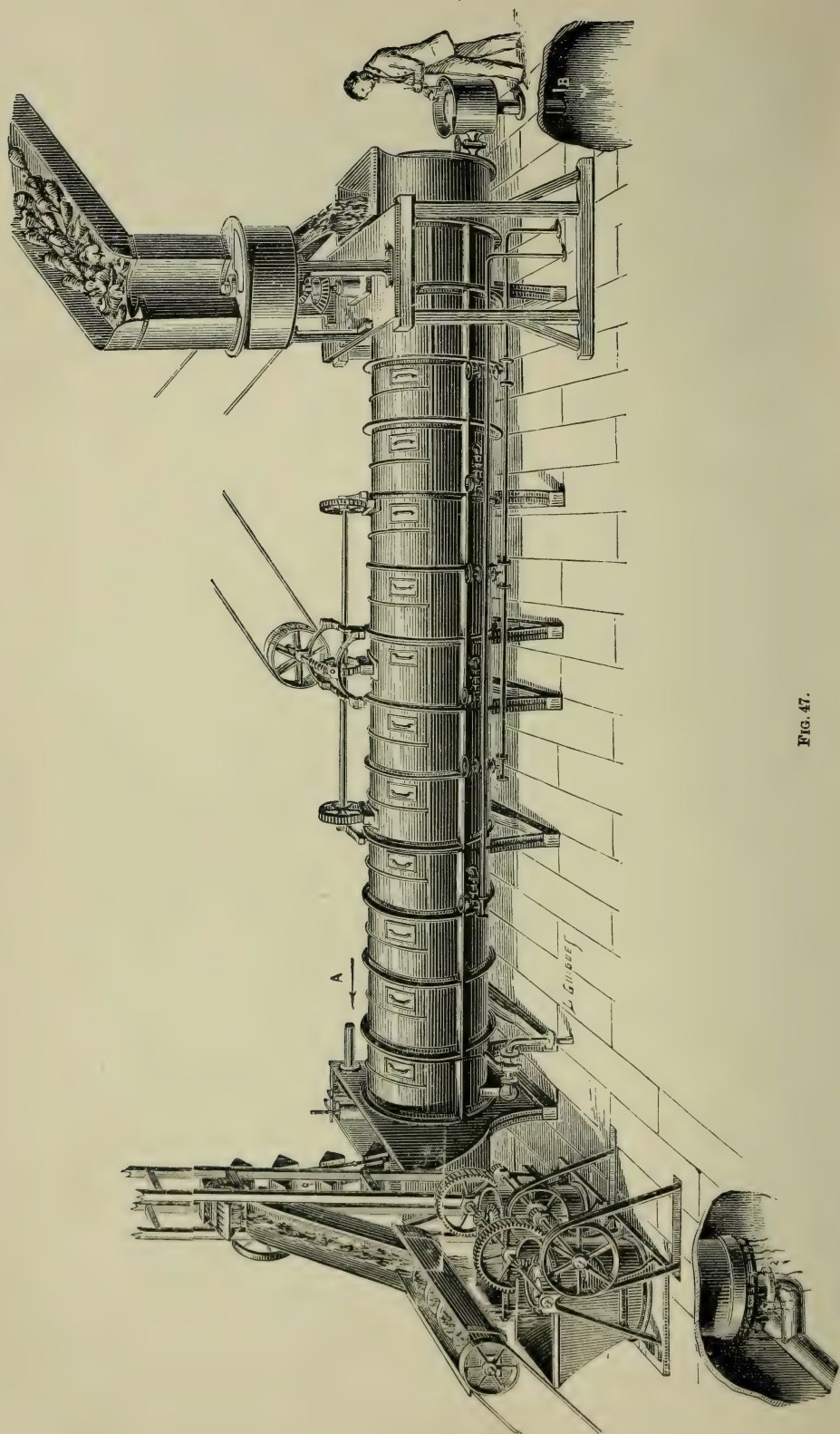


FIG. 47.

into the diffusers. The exhausted cossettes, or pulp as they are termed, are dropped into a channel below and thence carried to the continuous presses by a chain and bucket elevator.

"As I have indicated, the line battery differs from the circular only in the arrangement of the diffusers and the carrier necessary to charge them.

"Fig. 9 illustrates a circular battery, Riedel's system, constructed by the Hallesche Maschinenfabrik, Halle a. S.

"THE CONTINUOUS DIFFUSER.

"Since the invention of what is termed the German diffusion process, by Robert, it has been a favorite idea to devise a continuous diffuser. Robert himself attempted this, but without success. About six years ago Mr. Charles invented a continuous diffuser, which was afterwards successfully modified by Mr. Peret, of Roye, France. The following description of the continuous diffuser has been taken from the Bulletin de la Société Industrielle d'Amiens, 1882:

"The continuous diffuser consists of an iron cell, cylindrical in form, resting horizontally upon a foundation of masonry. Within this cell is a perforated iron cylinder, 1.30 meters (4.26 feet) in diameter and 11.20 meters (36.74 feet) in length. The axis is formed by a smaller cylinder. Between these two cylinders is a helix, pitch 70 centimeters (2.3 feet). The inner cylinder is revolved by a suitable connection with a shaft. The speed of revolution is so adjusted that it requires 60 minutes for the beet cuttings to traverse the length of the helix. The cossettes are continually immersed in water. The water enters the cell at the end where the exhausted cossettes are expelled. An automatic arrangement controls the amount of water admitted and keeps it at a certain level. The water gradually becomes charged with sugar and finally leaves the cell at the end where the fresh cossettes enter it.

"The conditions for a good diffusion are fulfilled when the cossettes and water move in opposite directions, the juice becoming more and more concentrated as it passes cossettes richer and richer in sugar.

"The water enters at a temperature of 30° C. (86° F.). It is heated as it passes the coils placed between the fixed cell and the revolving cylinder, and its temperature is gradually increased to 75° C. or 80° C. (167° or 176° F.), and then, as it strikes fresh cossettes, it gradually becomes colder and leaves the diffuser at a temperature of 50° C. to 60° C. (122° to 140° F.).

"Three small vertical test cylinders are placed at equal distances from one another and serve for determining the specific gravity and the temperature of the juice. These observations are made at regular intervals and the results are entered in a note-book.

* * * * *

"In the ordinary form of diffusion battery the ten or twelve diffusers demand the constant attention of a skilled workman. He must open and close the various valves from six to seven hundred times in the twelve hours he is on duty.

"The continuous diffuser requires but little attention after one has regulated (1) the speed of the slicer, (2) the speed of the elevator which removes the exhausted cossettes, (3) the speed of rotating cylinder, (4) the pressure of steam on the coils, (5) the exit of the juice which controls the entrance of the water.

"It is only necessary to note the temperature at intervals and regulate the pressure on the coils. The temperature and the quality of the beets are the only variables. One man and a boy are sufficient to conduct the diffuser, beet slicer, and pulp presses.

"The following certificate will explain itself.

"Complete machinery for working 2,000 hectoliters (44,000 gallons) of juice in twenty-four hours, including engines, beet slicer, the diffuser (with elevator for exhausted cossettes), Klusemann pulp presses, and transmission of power, etc.; total cost, 50,000 francs (\$10,000); cost of repairs per season, 500 to 700 francs (\$100 to \$140).

"Labor per ton of beets worked, not including washing the beets, 16 centimes (3.2 cents).

Results obtained.

Mean density of 2,000 hectoliters of juice.....	*1.036
Beets, per 100 liters, and each degree of density.....kilograms..	21.00
Masse cuite per 100 kilograms of beets.....liters..	6.63
Masse cuite per hectoliter of juice.....do.....	1.45
First sugar, white, per 100 kilograms of beets.....kilograms..	4.492
Sugar per 100 liters of masse cuite.....do.....	68.
Second molasses per 100 kilograms of beets.....liters..	4.06
Second molasses per 100 liters of first masse cuite.....do.....	61.
Second sugar per hectoliter of masse cuite.....do.....	44.
Molasses per 100 kilograms of masse cuite.....do.....	44.
Beets, per 100 kilograms of masse cuite.....kilograms..	+1,000.
Pulp per 100 kilograms of beets.....do.....	40.
Sugar per 100 kilograms of pulp.....do.....	0.41

ROUSSEAU,

Chef de fabrication à Frayieres.

The following table shows the results obtained in the sugar house at Roye (Somme), France :

Table showing the extraction—Roye sugar house (France), 1881 and 1882.

Date.	Specific gravity of the beet.	Specific gravity of the juice.	Temperature.	Juice.	Sugar left in the cossettes.
1881.			°C.	Hectoliters.	Per cent.
September 28.....		1.023	66	900	.....
September 29.....	1.050	1.026	66	1325	.....
September 30.....		1.028	66	1495	0.82
Averages.....	1.050	1.026	66	1217	0.82
October 1.....	1.053	1.0295	70	1275	0.57
October 2.....		1.029	69	300	.....
October 3.....	1.0515	1.029	69	1500	0.58
October 4.....	1.0535	1.0339	66	1725	0.55
October 5.....	1.0541	1.0333	60	1575	0.47
October 6.....	1.0521	1.030	66	1700	0.45
October 7.....	1.0555	1.032	63	1725	0.40
October 8.....	1.053	1.030	66	1575	0.45
October 9.....	1.0525	1.0355	78	1000	0.44
October 10.....	1.0525	1.036	75	1825	0.37
October 11.....	1.0535	1.032	73	1650	0.51
October 12.....	1.0525	1.033	73	1750	0.45
October 13.....	1.052	1.034	73	1750	0.42
October 14.....	1.0545	1.034	73	1750	0.48
October 15.....	1.054	1.036	73	1725	0.57
October 16.....	1.054	1.033	73	2000	.....
October 17.....	1.0555	1.035	71	1775	0.45
October 18.....	1.054	1.0345	72	2000	0.44
October 19.....	1.057	1.035	72	1700	0.55

* Or 3°.6.

† 2,200 pounds.

Table showing the extraction, etc.—Continued.

Date.	Specific gravity of the beet.	Specific gravity of the juice.	Temperature.	Juice.	Sugar left in the cossettes.
1881.			°C.	Hectoliters.	Per cent.
October 20.....	1.0535	1.032	70	1675	0.50
October 21.....	1.055	1.033	66	1600	0.57
October 22.....	1.0548	1.033	69	1200	0.60
October 23.....	1.055	-----	76	300	0.45
October 24.....	1.0535	1.030	77	1700	0.48
October 25.....	-----	1.030	78	1800	-----
October 26.....	1.055	1.0347	78	1800	0.52
October 27.....	1.049	1.0349	78	1850	0.40
October 28.....	1.051	1.035	78	1900	0.38
October 29.....	1.055	1.0353	77	1975	0.39
October 30.....	1.055	1.0377	78	2000	0.40
October 31.....	1.054	1.0378	78	1875	0.41
Averages.....	1.0549	1.0339	71	1725	0.51
November 1.....	1.0525	1.0367	78	1950	0.40
November 2.....	1.054	1.0367	79	1950	0.39
November 3.....	1.053	1.0364	79	1925	0.39
November 4.....	1.051	1.0369	79	2025	0.40
November 5.....	1.054	1.0378	79	1975	0.43
November 6.....	1.055	1.0366	79	1450	0.44
November 7.....	1.054	1.0365	79	1875	0.54
November 8.....	1.0518	1.0365	80	1900	0.44
November 9.....	1.053	1.0365	80	2000	0.44
November 10.....	1.053	6.0363	80	1825	0.37
November 11.....	1.0525	1.0368	80	1625	0.44
November 14.....	1.052	1.0381	89	1275	0.36
November 15.....	1.052	1.0372	72	1925	0.40
November 16.....	1.0565	1.0372	75	2000	0.39
November 17.....	1.056	1.0366	76	2000	0.39
November 18.....	1.0555	1.0363	75	1925	0.40
November 19.....	1.052	1.0358	78	1950	0.44
November 20.....	-----	1.0357	78	1400	-----
November 21.....	1.055	1.0357	72	1775	0.40
November 22.....	1.055	1.0357	74	2625	0.32
November 23.....	1.051	1.0351	76	2000	0.34
November 24.....	1.055	1.035	77	2000	0.36
November 25.....	1.053	1.0357	78	2000	0.25
November 26.....	1.053	1.0349	78	2000	0.30
November 28.....	-----	1.0348	78	575	-----
November 29.....	1.0575	1.0348	77	1950	0.50
November 30.....	1.0525	1.0346	77	2025	0.48
Averages.....	1.0535	1.0361	77.5	1940	0.40
December 1.....	1.0525	1.0351	78	2000	0.43
December 2.....	1.054	1.036	78	2050	0.33
December 3.....	1.052	1.0365	79	1950	0.36
December 4.....	1.051	1.0333	83	1900	0.38
December 5.....	1.0505	1.0352	86	2000	0.37
December 6.....	1.050	1.0356	84	1975	0.38
December 7.....	1.051	1.0350	84	2000	0.39
December 8.....	1.053	1.0358	86	1975	0.35
December 9.....	1.049	1.0369	86	2000	0.48
December 10.....	1.0505	1.0357	85	1950	0.39
December 11.....	1.050	1.0364	85	825	0.36
December 12.....	1.051	1.0355	82	2000	0.32
December 13.....	1.050	1.0361	81	2000	0.35
December 14.....	1.0477	1.0359	80	2000	0.42
December 15.....	1.0495	1.0363	80	2000	0.37
December 16.....	1.0495	1.0357	80	2000	0.37
December 17.....	1.0485	1.0356	86	2000	0.44
December 18.....	1.050	1.0352	82	1375	0.44
December 19.....	-----	1.0326	85	450	-----
December 20.....	1.0525	1.038	82	2000	0.65
December 21.....	1.053	1.041	87	2050	0.79
December 22.....	1.0508	1.0403	87	2050	0.88
December 23.....	-----	1.0392	88	2000	-----
December 24.....	1.0461	1.0380	86	1575	-----
December 26.....	1.054	1.0387	87	1400	0.52
December 27.....	1.050	1.0383	89	2060	0.51
December 28.....	1.050	1.041	90	2000	0.52
December 29.....	1.0448	1.039	90	2000	0.46
December 30.....	1.0455	1.0395	90	2000	0.45
December 31.....	1.046	1.0396	91	2050	0.48
Averages.....	1.050	1.038	84.5	2000	0.44

Table showing the extraction, etc.—Continued.

Date.	Specific gravity of the beet.	Specific gravity of the juice.	Temperature.	Juice.	Sugar left in the cosettes.
1882.			°C.	<i>Hectoliters.</i>	<i>Per cent.</i>
January 2		1.0376	88	1425	
January 3		1.038	89	2000	
January 4	1.053	1.041	89	1975	0.57
January 5	1.0509	1.0374	88	2900	0.55
January 6	1.0505	1.039	88	2000	0.54
January 7	1.0495	1.0375	88	2000	0.57
January 8		1.039	87	1500	
January 9	1.048	1.0375	88	1575	0.57
January 20	1.052	1.0386	90	1250	0.55
January 21	1.051	1.038	90	1900	0.50
Averages.....	1.0513	1.038	88.5	1980	0.56

"It may be safely stated that in Germany and Austro-Hungary not less than 90 per cent. of the sugar-houses employ the diffusion process for extracting the juice. The proportion in France is much smaller, owing to the tax being based upon the sugar actually extracted. Since the passage of the new law, levying the tax as in Germany, many French sugar-houses have adopted this process. I believe that in a few years the diffusion will be the only process employed for extraction, except in a few districts where local conditions prevent its adoption.

"EVAPORATION.

"The economical evaporation of the juice is one of the most important problems with which the sugar manufacturer has to deal.

"The hydraulic presses yield 100 pounds of dilute juice per 100 pounds of beets. With the diffusion process this proportion is considerably larger, being 120 pounds dilute juice per 100 pounds of beets. It is evident from the above statements that a beet-sugar house employing the diffusion process must be supplied with evaporating facilities at least one-fifth greater than one employing hydraulic presses. Inventors have not been backward in their efforts to meet this demand for improvements in the apparatus for rapid and economical evaporation.

"One of the most recent and important improvements in multiple-effect apparatus is known as the Welner-Jelinek system.*

* Since the above was written three or four new multiple-effect pans have been invented in this country. Information concerning them may be had by addressing the Kilby Manufacturing Company, Cleveland, Ohio; Thomas Gaunt, 115 Broadway, New York; Geo. M. Newhall Company, Philadelphia; Fort Scott Foundry, Fort Scott. Other makers of evaporating apparatus are John Turl & Sons, No. 534 West Twenty-eighth street, New York; Edwards & Hauptman, 22 Front street, New Orleans; Joseph Oat & Sons, 228 Quarry street, Philadelphia; Whitney Iron Works, New Orleans; John S. Moore, 169 Gravier street, New Orleans; John H. Murphy, 123 Magazine street, New Orleans; H. Dudley Coleman & Co., No. 9 Perdido street, New Orleans; Leeds & Co., New Orleans; Colwell Iron Works, 74 Cortlandt street, New York; The Pusey & Jones Manufacturing Company, Wilmington, Del.; The Squier Manufacturing Company, Buffalo, N. Y.; Robert Deely, Brooklyn, N. Y.

"In this system the pans are arranged horizontally and the heating space is divided into two chambers—an upper and lower. This division into chambers permits the passage of the vapors from the upper to the lower, facilitating the discharge of the water of condensation, and increases the heating surface. These chambers are each subdivided into two others of unequal size. The shape of the pan reduces the danger of loss through particles of the juice becoming entangled with the disengaged vapors. In addition there is also the usual arrangement for diminishing this loss."

"TREATMENT OF THE JUICE.

"Preliminary to describing a few of the more important processes employed in the manufacture of sugar from the beet, it may be well to indicate briefly the usual method for treating beet juices.

"Unfortunately, the simple process employed for clarifying cane juices is not at all successful with the beet. Beet juice contains but slight traces, if any, of glucose or reducing sugar, whereas the cane juice usually carries a notable quantity of this substance.

"In treating beet juices a large excess of lime is added, usually from $2\frac{1}{2}$ to 3 per cent. Carbonic acid gas is then forced through the juice, and the excess of lime is precipitated in the form of a carbonate, and carries down with it mechanically many of the impurities. This operation is terminated when the lime precipitate becomes granular and settles readily. At this point there still remains about a gram and a half of lime (CaO) per liter of juice. After having been passed through filter-presses the juice is treated, boiling hot, with $\frac{1}{2}$ per cent. of lime, and carbonic acid is passed through it, until all the lime is precipitated. This operation is termed the *saturation*, the former the *first carbonation*. The juice is again filtered through presses. Its further treatment is very similar to that of the cane.

"Experiments have been made by Dr. Wiley* which indicate that a modification of this process could be successfully employed with cane juices. This method would be especially applicable in the manufacture of sugar from† sorghum or in the treatment of very dilute diffusion juices.

"The vacuum pans employed in boiling beet sugar are usually very high in proportion to their diameter, in order to enable the panman to build up large crystals.

"As a rule, in Germany, the first sugars are not washed, and polarize 96 per cent. In France, on the contrary, those houses having facilities for making white sugar usually do so, and turn out an article polarizing 99 per cent.

* Bulletin No. 3, Chemical Division, United States, Department Agriculture, 1884.

† For more recent experiments on a manufacturing scale, see Bulletins, Nos. 6 and 14.

"STOEBNITZ SUGAR-HOUSE.

"This sugar-house is located about 15 miles from Halle. The works were erected by a stock company. The stock is divided into 150 shares of 6,000 marks (\$1,500). Each share-holder binds himself to furnish the beets from a certain number of acres of land, for which he receives 22 marks (\$5.17) per 1,000 kilograms (2,200 pounds), and, in addition, the pulp from his beets. Other farmers are paid 25 marks (\$5.87) per ton of 1,000 kilograms, and receive no pulp; but, if they prefer it, they are paid in the same way as the share-holders. This insures a plentiful supply of beets, and is the plan generally adopted by German sugar-houses.

"The soil of the surrounding country tributary to Stoebnitz is rather a light clay, easily worked, and capable of producing an excellent beet. The sugar-house furnishes the seed to the farmers. Selected samples from the field have polarized as high as 22 per cent. sucrose. Glucose is only present in immature beets, or in those which have sprouted in the silos.

"The Stoebnitz sugar-house is located in the center of a great depression, the neighboring hills sloping gradually to it. It is readily accessible by good country roads radiating in all directions. Its location possesses many advantages, and but one serious disadvantage. This latter is its distance from rail communication.

"The greater part of the machinery has been constructed by the Hallesche Maschinenfabrik. Mr. Roediger, a mechanical engineer connected with this establishment, kindly accompanied me on my visit to Stoebnitz.

"As the acreage tributary to Stoebnitz has increased from time to time, the works have gradually reached their present magnitude through successive enlargements; hence, as one would naturally expect, the arrangement of the buildings and machinery is not such as would give the greatest economy of labor. Old walls, constructed for a smaller sugar-house, have imposed many restrictions upon the manager in the disposition of his machinery. Notwithstanding the disadvantages under which he labored, he has succeeded in building up a model sugar-house.

"The carts and wagons are driven directly into the beet shed and discharge their loads through trap-doors into the receiving-room below. Here a large force, composed mostly of women, throw the beets upon the carrier, which transports them to the washers, two in number. The washed beets are then carried by an elevator to an upper story and dumped into cars, to be weighed by the excise officer. The weighed beets are then sliced and conveyed to the two diffusion batteries. These batteries are ranged in a double line, twelve diffusers in each line. They have an united capacity of 600 tons of 2,200 pounds, in twenty-four hours. The batteries are of the Riedel type, constructed some years since. Between the two lines is a large trough to receive the

exhausted cossettes, whence they are conveyed to six continuous pulp-presses, four of the type known as Klusmann and the other two Bergreen.

"The pressed pulps still contain from 75 to 85 per cent. of water, and in this moist condition are 40 per cent. of the weight of the beets worked. This pulp is very valuable as cattle food, and sells for about \$1.70 per ton. The relative values of diffusion and the old hydraulic press pulps is still a much debated question in some sugar countries. The juice from the diffusers is conducted to a calorisor, where it is heated to about 90° C. (194° F.) and is then treated with lime.

"By the use of calorisors (Fig. 15) it is claimed that the heat expended in the process of diffusion is not lost, and that subsequent op-

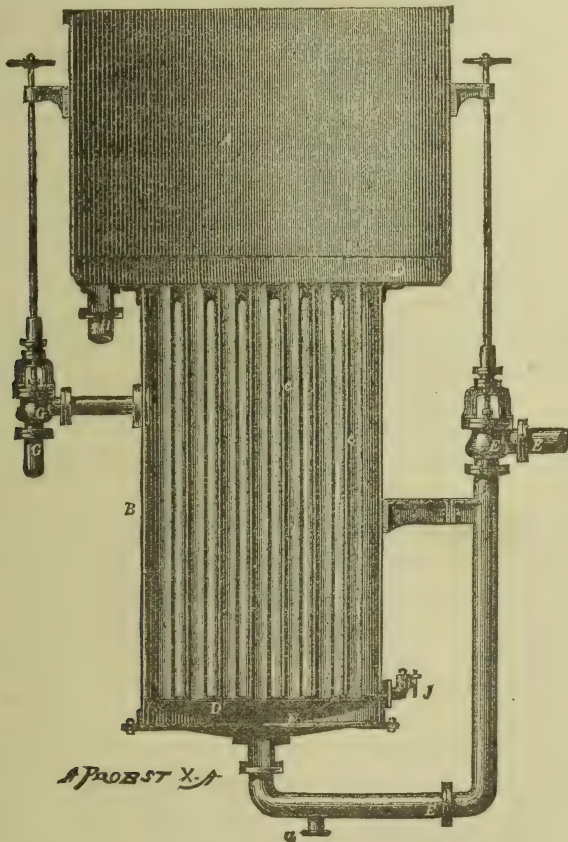


Fig. 48.

erations are carried on much more rapidly than by the old method. Generally in France the juice is conducted into tanks, whence it is drawn off as needed for the carbonatation pans. Consequently it loses much of its heat, and the first carbonatation demands a longer time. This entails a much larger number of carbonatation pans. As at Stoebnitz,

also generally in Germany, the carbonatation pans are covered and the foam is kept down by a jet of live steam. In many French sugar-houses, where large open pans are employed, the foam is beaten down by an arrangement of paddles, driven by machinery, and often in addition by a jet of steam.

"The French manufacturer usually commences his first carbonatation at a low temperature, 40° C. (104 F.), which he gradually increases as the carbonatation progresses. By this means he claims that he avoids dangerous combinations between the lime, carbonic acid, and the sugar.

"At Stoebnitz about 2½ per cent. (of the weight of the beets) of lime is employed in the defecation, and the usual quantity, about 1½ grams per liter, is left in the juice after the first treatment with carbonic acid.

"The carbonatated juice, including the suspended precipitate, is sent to the filter-presses. The precipitate is washed with hot water and the washings are added to the filtrate. The filtered juice is treated with a second portion of lime, one-fourth of 1 per cent. of the weight of the beets; the lime is again precipitated by carbonic acid and the juice is passed through the filter-presses; a third portion, about a liter and a half of cream of lime, is then added and afterwards saturated with sulphurous acid. After passing the filter-presses, the juice is concentrated to 23° B.

"This sirup is treated with a final and very small portion of lime, which is precipitated by carbonic acid, and the sirup after filtration is boiled to grain.

"This sugar-house has two double effects, one of the ordinary type, and the second the Welner-Jelinek system.

"The vacuum pans have a capacity, one of 60,000 pounds dry sugar, and the other 25,000 pounds.

"The massecuite is dropped into small coolers, each of about one hectoliter capacity. These coolers are shaped like the frustum of a pyramid, and can be readily transported by means of a small two-wheeled carriage. (See Fig. 49.)

"It requires but little more time to fill these coolers than to drop the masse-cuite into the larger mixers common in Louisiana. The masse-cuite is expelled from the cooler by compressed air. The cooler itself weighs about 50 pounds, and when filled with massecuite, 400 pounds.

"The manager of the Stoebnitz sugar-house stated that he obtains from 4 to 6 per cent. (of the weight of the massecuite) more sugar by allowing it to become perfectly cold before swinging out.

"The next portion of these works that deserves more than this passing notice is the chemical laboratory. It is evident, from the fact that a very large proportion of sugar-houses employ chemists, that the German manufacturers fully appreciate the advantage of a chemical control of the work. Most of the important improvements in processes have had their origin in the laboratory.

"The Stoebnitz works have an excellent laboratory. It is located on the second floor and occupies two large, well lighted and ventilated rooms. The chemist and his assistant keep a chemical control of all the processes. The juice and diffusion pulps are examined at frequent intervals. Samples of the beets from each lot brought to the sugar-house are also analyzed. The laboratory is one of the busiest parts of the sugar-house.



Fig. 49.

"Stoebnitz has unsurpassed advantages for the economical generation of steam. Within 600 yards of the sugar-house there is an inexhaustible mine of lignite or brown coal. This lignite is mined very extensively, and transported upon a tram-way to the works, and is dumped into large bins above the boilers. By an automatic arrangement it is fed directly upon the fires.

"Lignite furnishes an excellent fuel, but yields only about a third as much heat as bituminous coal. The ash amounts to about 14 per cent. The cost of lignite delivered at the machine works in Halle is less than \$1 per ton. Good bituminous coal costs in the same locality from \$3.75 to \$4.50 per ton.

“CAMBURG SUGAR-HOUSE.

“The sugar factory at Camburg is situated on the river Saale, about 25 miles from Halle. The buildings are located about 100 yards from the river, from which the works derive an unfailing supply of water.

“Comparatively few beet-sugar houses have equal water advantages. In most factories the vapors from the evaporating juices are condensed and the water is used again and again. This necessitates a special arrangement for cooling the water. This consists of a frame-work, supporting bundles of willow twigs, over which the water passes, falling from one bundle to another, until it finally reaches the reservoir which supplies the factory.

“A branch railway has been constructed, connecting with the main line, and beets are brought in and dumped directly into the carriers. These latter consist of a system of narrow cement-lined trenches, through which a constant stream of water is flowing.

“The rapidly-flowing current propels the beets, and finally drops them into a box, from which they are carried by an elevator to the washers, two in number.

“This hydraulic carrier, as it is termed, is a very convenient and economical method for transporting beets, and for factories having a good water supply can be highly recommended. The trenches are easily constructed, and are so arranged that they admit of ready access for repairs. The water of condensation furnishes the supply for the conduits.

“The washed beets fall upon a perforated plate, which is rapidly shaken by machinery in order to throw off the water and dry them as much as practicable. This is evidently very important, as an excise tax is levied on the washed beets. The water so thrown off amounts to at least 2 per cent. of the weight of the beets.

“The diffusion battery is of the Hallesche Maschinenfabrik construction, and has all the latest improvements.

The diffusers are arranged in a circle and discharge the pulp into a central basin, whence it is lifted to the presses by a chain and bucket elevator. The helix form of elevator for pulp is no longer used with Riedel's battery, as it will not work satisfactorily at so great an angle as 45°.

“The presses are of the Bergreen type. It will be noticed that two presses only are required to do the same work as three at Stoebnitz. The process employed at Camburg for extracting the sugar from the juice does not differ materially from that in vogue in most of the sugar-houses in France. The only difference is in the reheating of the juice coming from the diffusers, before carbonatation; this is accomplished by two calorisors, in one of which the temperature is raised to a certain degree by exhaust-steam and in the other to 90°C. by direct steam. I would again call attention to this idea of conducting the first carbonatation at a high temperature.

"Not having been able to secure analyses of the juice, I can not say whether the results are better than by the old process or not. This method certainly has the advantage of hurrying the precipitation, and by diminishing the time required, a few pans will do the work of several working in the old way, and there is still another advantage. Since the precipitation is accomplished so much more rapidly, it is evident that the carbonic acid is better utilized and that the waste is reduced to a minimum.

"A series of montes jus are employed to force the juice to any part of the sugar-house. Instead of steam pressure, compressed air is employed. As soon as a monte jus is emptied, the air-pump is connected with it and the air is forced into another. By this method the power expended in compressing the air is economized. The use of compressed air instead of high-pressure steam is not only much more economical, but in addition possesses the advantage of not injuring the juice.

"The quantities of lime (CaO) employed are as follows: 1st. Carbonation 2.25 to 2.5 per cent. of the weight of the beets. Saturation, .25 per cent. 1.0 to 1.5 grams lime per liter of juice is left after the first carbonation; after the saturation .03 to .04 gram.

"The lime is placed in wire baskets, which are lowered into the carbonation pans. This plan is considered preferable to adding slacked lime.

"The lime precipitate, usually termed scum or mud, is washed in the filter-press by a stream of water. This precipitate amounts to about 6 per cent. of the weight of the beets worked.

"While on this subject it may be well to speak of two of the more important processes for the recovery of the sugar left in the scums.

"The proper treatment of the scums is of very great importance. Unwashed scums contain about 4 per cent. sugar, and amount to at least 9 or 10 pounds per hundred pounds of beets. This corresponds to a loss of .36 to .40 per cent. sugar, or 7.9 to 8.8 pounds of sugar per long ton of beets.

"By means of an ingenious device for washing, Mr. Charles Gallois has succeeded in reducing the loss of sugar to from .20 to .40 per cent. of the scums.

"This device consists of a three-way valve, so arranged that the filter-press can be placed in communication with either the monte jus containing the scums, a mixture of scum and hot water, or boiling water. This simple device can be attached to any filter-press.

"To operate the press: Open wide the valve connecting with the scums. The press soon fills. When the volume of juice flowing from the press diminishes perceptibly, change the valve and admit scums diluted with water. The density of the juice will now rapidly diminish. Open the water valve and pass boiling water through the press until the density indicates that but little juice is being extracted. The last portions of dilute juice are employed to slack lime for the defecation.

"Another successful method is as follows: The scums are pressed in an ordinary filter; the residue, or precipitate, is removed from the filter, thoroughly mixed with water, and is again pressed. This results in a very decided decrease in the weight of the scums, showing that a large proportion of the sugar has been extracted. It is claimed that this method reduces the danger of redissolving the impurities contained in the lime precipitate.

"When this factory was constructed two years since the process for treating the juice with sulphurous acid and entirely suppressing the use of bone-black was not yet an assured success, consequently, rather than risk a new and still uncertain process, the new works were supplied with a battery of closed filters and a Langen-Schatten bone-coal kiln. Since this time the sulphurous acid process has advanced very much in favor with sugar manufacturers, and now many sugar-houses entirely suppress the use of bone-black.

"For evaporation this house has one triple-effect, and for boiling to grain, one vacuum pan. The barometric vacuum pump is used.

"TREATMENT OF THE MASSECUITE.

"The massecuite is dropped into small coolers, similar to those at Stoebnitz (Fig. 16). 2 feet 6 inches deep, 10 inches long, 1 foot 6 inches wide at top, and 1 foot at the bottom. Capacity approximately 1.4 hectoliters.

"After remaining 12 hours in the cooling room the massecuite is expelled from the cooler by compressed air, and is dropped into the mixer below. It is claimed that by the use of these coolers the yield of first sugar is largely increased.

"Dr. Prella, superintendent of the Camburg works, made an experiment two or three years since, to determine if this is really the case. He took equal volumes of the massecuite, then swung out the sugar from one immediately after dropping it from the pan; the yield was 62 per cent. sugar. The second portion he set aside 12 hours, until it was perfectly cold; this yielded 68 per cent. sugar, a gain of 6 per cent. He now invariably allows the massecuite to become cold before swinging out. The following are a few percentages taken from Dr. Prella's notebook and show the amount of sugar obtained several days in succession last season: 75 per cent., 74 per cent., 74.2 per cent., 77 per cent., 71 per cent., 72 per cent., 76 per cent.

"The Camburg sugar-house has not yet finished its second campaign. Its first year's work was remarkably successful. The house being supplied with every facility for good work, and having an exceptionally good harvest of beets, both as regards quantity and quality, yielded a very large profit to the owners. The cost of the sugar-house was about \$225,000. Its capacity is 300 long tons per 24 hours, or 30,000 tons for the campaign. This establishment at Camburg is in every respect a model sugar-house.

“DETAILED STATEMENTS OF THE WORKINGS OF SEVENTEEN GERMAN
SUGAR-HOUSES.

“In order to determine a basis for taxing the beet-sugar industry, the German Government selects certain sugar-houses and requires them to make detailed reports. In these reports each sugar-house is designated by a letter of the alphabet. Care is taken to select only those factories which are fair representatives of the districts in which they are located.

“The copy of these tables for 1882 and 1883, which accompanies this report, is given to show as briefly as possible statistics of the yield and expenses in the manufacture of beet sugar.

25474—Bull. 27—16

Designation of sugar-house....	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	O.	P.	Q.	R.
Polarization calculated on weight of beet.....	10.72	11.44	11.86	10.83	10.85	10.90	10.50	10.90	10.05	11.20	10.47	9.66	10.44	10.53	10.09	11.47	10.90
Non-sugar calculated on weight of beet.....	2.65	2.62	2.77	2.66	2.95	2.82	2.60	2.68	2.87	2.54	2.59	2.94	2.45	2.86	2.89	3.93	2.50
Coefficient of purity.....	80.21	81.36	81.07	80.28	78.62	79.40	80.15	80.24	77.80	81.30	80.14	76.66	80.99	78.64	77.73	74.40	81.37
Available sugar.....	8.70	9.31	9.60	8.69	8.53	8.76	8.42	8.77	7.82	9.13	8.39	7.40	8.44	8.28	7.84	8.53	8.86
Masse-cuite.....	12.19	12.27	12.06	11.53	11.89	11.92	11.11	10.84	13.73	11.99	11.36	11.38	13.32	10.63	10.86	11.65	11.36
Polarization of masse-cuite.....	84.90	87.60	84.34	85.73	84.40	85.37	85.60	86.94	84.70	85.58	84.43	83.04	85.48	84.10	85.27	83.90	84.46
Sugar obtained from the masse-cuite.....	83.76	80.25	77.29	76.54	75.29	76.87	76.69	80.67	73.42	75.70	73.77	76.97	75.25	82.68	72.83	76.53	81.82
Sirup obtained from the masse-cuite.....	7.92	20.29	21.68	23.42	24.61	21.16	25.74	12.85	14.22	23.92	26.23	19.68	10.85	17.15	30.58	23.52	9.98
Sugar obtained.....	10.21	9.85	9.40	8.82	9.14	9.14	8.51	8.75	10.05	9.07	8.38	8.77	10.02	8.77	7.90	8.94	9.30
Sirup obtained.....	0.97	2.50	2.61	2.70	2.93	2.51	2.86	1.39	2.14	2.87	2.78	2.24	1.45	1.82	3.26	2.74	1.13
Polarization of the first products.....	95.89	95.67	95.40	95.70	95.60	96.03	95.60	96.66	94.14	95.63	96.40	94.42	94.98	95.35	96.90	94.22	95.14
Valuation of the sugar in dollars per 100 lbs. (German = 110 lbs.).....	\$5.80	\$6.87	\$6.73	\$6.80	\$6.93	\$6.98	\$7.00	\$6.95	\$6.75	\$6.76	\$7.03	\$6.56	\$6.65	\$6.86	\$7.49	\$6.55	\$6.84
Cost of sugar in dollars per 100 lbs. (German = 110 lbs.).....	\$5.52	\$5.73	\$5.65	\$5.86	\$6.02	\$6.09	\$6.10	\$6.13	\$6.17	\$6.17	\$6.45	\$6.02	\$6.12	\$6.50	\$7.12	\$6.35	\$6.89
Beets worked per hectoliter of brown coal.....lbs.	196.9	233.2	178.2	277.2	198.0	242.0	407.0	372.9	209.0	200.2	195.8	172.7	213.4	320.1	200.2	234.3	232.1
Receipts per ton (2,200 lbs.) of beet roots.....	\$14.16	\$14.14	\$12.92	\$12.75	\$13.18	\$13.30	\$12.64	\$12.40	\$13.06	\$12.96	\$12.62	\$12.10	\$13.52	\$12.36	\$12.70	\$12.13	\$12.98
Expenses, not including mortgages, etc.....	11.56	11.92	10.88	11.08	11.52	11.68	11.10	10.96	12.10	11.88	11.64	11.04	12.68	11.72	12.12	11.98	13.06
Gross profit per ton (2,200 lbs.) of beets.....	2.60	2.22	2.04	1.64	1.64	1.60	1.52	1.42	1.14	1.06	0.98	0.94	0.82	0.62	0.58	0.34	.....
Gross loss per 100 lbs. of beets.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

A.—EXPENSES FOR BEETS AND TAXES PER TON (2,200 LBS.) OF BEETS.

Beets.....	\$4.94	\$5.58	\$5.02	\$5.08	\$5.58	\$5.32	\$4.86	\$5.08	\$5.48	\$4.94	\$5.42	\$4.84	\$5.48	\$6.10	\$5.36	\$5.32	\$6.42
Taxes.....	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76
Totals.....	8.70	9.34	8.78	8.84	9.34	9.08	8.62	8.84	9.24	8.70	9.18	8.60	9.24	9.86	9.12	9.08	10.18

Campaign of 1882 and 1883—Continued.

B.—MANUFACTURING EXPENSES PER TON (2,200 LBS.) OF BEETS.

Designation of sugar-house....	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	O.	P.	Q.	R.
Fuel	\$0.90	\$0.80	\$0.80	\$0.82	\$0.67	\$0.82	\$0.68	\$0.63	\$0.86	\$0.86	\$0.87	\$0.80	\$1.00	\$0.61	\$1.05	\$0.76	\$0.81
Light	.04	.02	.04	.02	.07	.02	.01	.01	.03	.02	.03	.03	.04	.02	.03	.04	.07
Freight	.04	.04	.04	.04	.07	.12	.09	.07	.06	.16	.03	.04	.05	.02	.09	.01	.07
Sacking sugar	.02	.04	.02	.06	.06	.02	.03	.02	.06	.04	.03	.03	.02	.02	.05	.01	.07
Buildings and repairs	.06	.06	.08	.04	.03	.01	.02	.05	.02	.03	.01	.02	.03	.02	.14	.06	.05
Bone-coal	.10	.12	.12	.06	.09	.11	.09	.08	.11	.10	.05	.07	.09	.08	.07	.12	.05
Wages	.62	.62	.40	.44	.65	.43	.44	.37	.61	.69	.59	.58	.62	.38	.43	.63	.66
Machinery and repairs	.20	.22	.28	.24	.13	.17	.18	.22	.17	.18	.13	.19	.37	.18	.21	.29	.12
Provisions	.10	.06	.06	.06	.07	.07	.06	.07	.07	.07	.07	.06	.11	.06	.09	.07	.06
Oil for vacuum pans	.02	.02	.02	.02	.01	.01	.01	.01	.02	.01	.01	.01	.01	.01	.01	.03	.01
Machines, oil and grease	.02	.02	.02	.02	.02	.01	.04	.03	.02	.02	.02	.02	.01	.01	.01	.01	.01
Muriatic acid	.02	.02	.02	.02	.02	.01	.01	.02	.02	.03	.01	.02	.01	.02	.01	.06	.04
Minor apparatus	.02	.02	.02	.02	.02	.01	.06	.05	.02	.03	.01	.01	.01	.01	.04	.05	.01
Lime	.06	.04	.04	.08	.10	.10	.06	.05	.11	.07	.01	.04	.24	.07	.06	.06	.05
Carvas and linen	.06	.04	.02	.06	.05	.04	.05	.02	.02	.05	.04	.03	.18	.04	.02	.04	.01
Wood, coal, and coke	.04	.04	.02	.02	.03	.02	.01	.05	.05	.05	.05	.05	.11	.04	.03	.03	.03
Spirits, osmose paper	.02	.....	.....	.02	.....	.01	.....	.....	.04	.01	.....	.01	.....	.....	.....	.....	.02
Totals	2.34	2.20	2.00	1.84	1.87	1.97	1.77	1.70	2.22	2.42	1.95	2.00	2.94	1.57	2.41	2.23	2.10

C.—OTHER EXPENSES PER TON (2,200 LBS.) OF BEETS.

Insurance	\$0.04	\$0.04	\$0.03	*\$0.05	\$0.04	\$0.04	\$0.02	\$0.03	\$0.06	\$0.04	\$0.05	\$0.03	\$0.06	\$0.03	\$0.06	\$0.04	\$0.07
Interest and discount	.23	.20	.....	.22	.10	.36	.51	.23	.33	.44	.28	.36	.31	.17	.31	.39	.43
Salary	.14	.16	.08	.09	.12	.08	.08	.11	.11	.14	.10	.10	.10	.08	.16	.12	.14
Various expenses	.10	.08	.04	.11	.07	.08	.08	.05	.14	.14	.02	.06	.05	.07	.09	.12	.09
Totals	.51	.48	.15	.47	.33	.56	.69	.42	.64	.76	.52	.55	.51	.35	.62	.67	.73

"THE EXTRACTION OF THE SUGAR FROM THE MOLASSES.

"It has long been a problem with sugar manufacturers to devise a method for extracting the sugar from the molasses. The importance of this problem is such that it has led many of the most noted inventors in the field of sugar manufacture to investigate it. It is stated that in France 15 per cent. of the sugar in the beet remains in the molasses. This corresponds to a loss of about $1\frac{1}{2}$ per cent. on the weight of the beet. This loss is even more important in the beet than the cane sugar manufacture. The beet molasses is very highly colored and has an extremely disagreeable taste. In fact, it can only be utilized for the manufacture of vinegar or for distilling purposes.

"Quite a number of processes have been proposed for the extraction of the sugar from molasses, a few of which have been successful. From a chemical point of view this is a comparatively easy problem, but commercially or mechanically speaking it is an extremely difficult one.

"It is a well-known fact among manufacturers that all the sugar can be readily separated by precipitation as a barium saccharate, but the cost of the barium salt precludes its use. Again, the processes known as "elution," depending upon the precipitation of a lime saccharate and subsequent washing of this precipitate with dilute alcohol, are both chemically and mechanically successful. The elution processes, however, can only be employed in those countries where alcohol either pays a very low excise tax, or is entirely free from tax when used for manufacturing purposes. These brief statements merely indicate the difficulties which the chemist and manufacturer have been compelled to face. In many instances, after a long series of experiments in his laboratory, the chemist has been compelled to yield to difficulties not always chemical, but often of a purely mechanical nature.

"For example, he has succeeded in producing a saccharate of lime, containing all the sugar in the molasses; but the saccharate would contain many impurities which could only be eliminated by careful washing. On attempting to wash this combination between the lime and sugar the filter-press would soon clog and refuse to do the work. Had the precipitated saccharate been granular this would not have been the result. Notwithstanding these difficulties and failures two successful processes have been devised. In the more recent, the Steffen separation process, the inventor has succeeded in readily producing a granular precipitate of tribasic saccharate of lime. The other process is termed the Strontium Process. Not having had an opportunity to visit works employing strontium, I shall only describe the Steffen process.

"CHEMISTRY OF THE SEPARATION PROCESS.

"Very complete investigations have been made of the lime saccharates, with the especial object of utilizing their properties in the separation of sugar. The lime saccharates are three in number :

Monobasic ($C_{12}H_{22}O_{11}$), CaO .

Dibasic ($C_{12}H_{22}O_{11}$), $2\ CaO$.

Tribasic ($C_{12}H_{22}O_{11}$), $3\ CaO$.

"Some chemists claim the existence of a fourth, the tetrabasic.

"If a portion of finely powdered pure quicklime be added to a 6 to 12 per cent. sugar solution, in the proportion of one molecule of lime for each molecule of sugar, the temperature of the solution being kept below 30° C. (86° F.), the monobasic saccharate of lime will be formed. This saccharate is perfectly soluble in water. It is necessary for the success of this experiment that the quicklime be recently calcined and finely powdered.

"If this solution of monobasic saccharate be heated it will be decomposed and the tribasic saccharate precipitated. To form the dibasic saccharate it is necessary to add an additional molecule of lime, under the same physical conditions as before. The dibasic saccharate may be separated by crystallization in the cold.

"The tribasic saccharate is much more important from a commercial point of view than the others. It is with difficulty soluble in 200 parts of water, but insoluble in a saturated water solution of the tribasic salt itself. When precipitated under certain well-defined conditions it is granular. Sugar can be completely precipitated in this combination from a dilute solution. This precipitate being crystalline can readily be washed in a filter.

"To form the tribasic saccharate proceed as follows: Dissolve a certain quantity of sugar in water, making a 6 to 12 per cent. solution. By means of some suitable arrangement keep this solution at a temperature below 30° C (86° F.). For every molecule of sugar add three molecules of very finely-powdered and freshly-burned lime. The lime must be added in small portions, the solution being stirred constantly. The tribasic saccharate of lime will be precipitated.

"The following analyses show the composition of the saccharate obtained by the above method:

	By analysis.*	Calculation.
Carbon (C)	25.30	25.53
Hydrogen (H)	5.14	4.96
Oxygen (O)	38.12	48.23
Calcium (Ca)	21.44	21.28

* De la Diffusion. Par Jules Cartuyvels, p. 263.

"This saccharate is readily soluble in a sugar solution.

"The tribasic saccharate of lime can not be preserved any great length of time. Even at the end of two or three weeks the proportion of sugar decreases. The sugar decomposes and forms organic salts with the lime.

"The crystals of sugar obtained by the separation process resemble a confused mass of needles. If these crystals be dissolved in water and recrystallized they will assume the normal form.

* The peculiar form of these crystals is due to the presence of raffinose.

"THE SEPARATION PROCESS.

"I visited the sugar-house at Elsdorf, near Cologne, Germany, to examine into the practical workings of this process. The Elsdorf sugar-house was the first, I believe, to adopt it, and experiment upon a large scale. I afterwards visited the works of Mr. Max Le Docte, at Gembloux, Belgium, and examined the machinery, as adopted by Mr. Steffen after a year's experience in the practical application of his separation process. Plates Nos. 3, 4, 5, and 6 are from drawings kindly furnished me by Mr. Gèrard Oyens, of Paris.

"Before describing the separation process it may be well to speak of the

"COMPOSITION OF BEET MOLASSES.

"The averages of a large number of analyses of beet molasses show its composition to be about as follows:

	Per cent.
Sucrose	47.5
Reducing sugars	.5
Ash	9.3
Water	20.5
Organic matters	22.2
	100.0

"The percentage of reducing sugars as given above is rather high, as beet molasses does not usually contain more than a trace.

"The ash consists principally of salts of potassium, sodium, and magnesium. Phosphate of potassium is one of the principal constituents.

"The recovery of these mineral substances forms quite an industry in connection with the distillation of the molasses. One hundred pounds of molasses yields 10 pounds of black ash.

"The Steffen separation process depends upon the precipitation in the cold of the tribasic lime saccharate, sparingly soluble and of a granular structure.

"The freshly burned quicklime is first broken into small pieces by an ore-crusher, such as is used in the mining regions of this country. The broken lime is carried by an elevator to a mill, where it is ground to a very fine powder. This mill resembles in every respect an ordinary flouring mill. Special precautions are taken to prevent the lime powder from being inhaled by the workmen.

"The powdered lime is next conveyed by an elevator to another room, where it is passed through a fine wire gauze sieve. It is extremely important in this process that the lime be reduced as nearly as possible to an impalpable powder. Precautions are taken to remove any particles of iron from the powder by means of magnets. The powdered lime falls into a box holding a certain quantity, and is divided automatically into equal portions. From this box the portions are dropped at intervals into the mixer containing the diluted molasses. It is necessary that the temperature in this mixer should not rise above 30° C. (86 F.).

The lower the temperature the quicker the lime will combine with the sugar.

"The mixer consists of a large closed iron cylinder placed in a vertical position. Within this cylinder is a system of tubes arranged similarly to those in a pan of an ordinary double effect. Cold water (below 15° C., 59° F.) circulates about these tubes, entering below and discharging from above. The dilute molasses circulates through and above this system of tubes; a helix, revolved by suitable machinery, keeps the mixture in constant motion that it may be quickly cooled.

"The operations for the production of the tribasic lime saccharate are conducted as follows:

"A certain quantity of molasses is accurately measured. Water is added to it until the density of the solution is 12° Brix (6.6° B.), the percentage of sugar being from 7 to 8. This solution is cooled down to 15° C (59° F.); small portions of the powdered lime are then added at intervals of about a minute. The temperature increases a little after each addition of lime. Before adding more lime it must be again reduced to 15° C. This operation continues until lime has been added from ten to thirteen times, when the sugar is all precipitated. The workman determines this point by the density of a "proof" filtered from the mixture. The density of this filtrate should not be greater than 6° to 6½° Brix (3.5° B.). The total quantity of lime added is 93.4 pounds lime per 100 pounds of sugar in the molasses. When this process was first invented much larger quantities of lime were employed, often as much as 150 pounds per 100 pounds of sugar. The chemist at Elsdorf informed me that 93.4 pounds is sufficient.

"The unwashed lime saccharate resembles a dirty milk of lime. After leaving the mixer it is pumped to the filter-presses. The filters are fitted for washing the saccharate in the press. The mother liquor, containing all the impurities of the molasses, is used as a fertilizer. The water for washing the saccharate is carefully measured, and the same quantity per press is always employed. The wash water is afterwards used to dilute the molasses. By this means losses due to the slight solubility of the saccharate are avoided.

"It is important that the pressure on the filter-presses should not exceed two and one-half atmospheres. An excess of pressure over this limit will cause the saccharate to cake in the presses and it will be impossible to wash it.

"The filter-cloths require washing every four or five days. The cloths from one press per day are replaced by clean ones.

"The co-efficient of purity of the saccharate, *i. e.*, the percentage of pure saccharate in the crude, ranges from 97.5 to 98.5, and will average about 98.

"If one wishes to simply extract the sugar from the molasses, having obtained the tribasic saccharate, it is only necessary to decompose it with hot water, remove the lime by precipitation and filtration, and

evaporate the filtrate. But the greater number of establishments employing the Steffen substitution process work it in connection with beet-sugar houses. In this case the saccharate of lime replaces the lime for defecation.

"It is not sufficient to simply treat the saccharate with water to form a lime paste suitable for defecating. The objection is that the saccharate is in a granular state and is not readily acted upon by the carbonic acid. To produce a perfectly smooth milk of lime, free from grains, the saccharate is decomposed by hot juice. An average of 92 per cent. of the sugar contained in the molasses is extracted by this process.

"EXPENSES FOR LABOR.

"The extreme simplicity of this process is quite noticeable. There are no operations requiring skilled labor aside from the control exercised by the chemist. There is not an operation that can not be performed by a common laborer.

"At Elsdorf the workmen at the mixers receive one mark and a half per day (about 36 cents); at the filter-presses, one and a quarter marks (30 cents). These wages are about the average for the entire sugar-house.

"TREATMENT OF CANE MOLASSES BY STEFFEN'S PROCESS.

"Shortly after the announcement of the successful working of the separation process on a large scale certain London refineries employed a chemical expert to examine the process and report to them. As a successful application of this process would be of great importance to our cane planters, I obtained a copy of this report, and shall give those portions not already included in my description.

"After speaking of the complete success of the Steffen process in the treatment of beet molasses, Mr. Gill, the expert mentioned above, says:

"How far the same thing can be said in regard to its application to the molasses obtained in the manufacture or refining of sugar from the cane depends on a variety of considerations, of which the following are some of the most important:

"First. Is the sugar separated as pure as that obtained from the beet molasses, and is any of the glucose (altered and uncrystallizable sugar), which is always present in large quantities, precipitated along with the true cane sugar, and then again set free when the lime compound is decomposed by the carbonic acid, and if so how far the fact will interfere with the economy and utility of the process?

"The answers to these questions are not clear in the present state of the evidence. I am informed by Mr. Langen and his chemist that some glucose is precipitated, but that they do not know in how large a proportion. This would therefore have to be determined by experiment. I may say with certainty that if all or most of the glucose be precipitated with the sugar, and then again set free along with the sugar by the subsequent treatment with carbonic acid, that very little or no useful effect will be obtained, because glucose when present in solution with sugar greatly hinders, if it does not altogether prevent, the crystallization of an equal weight of the latter on evaporation.

"That the evil indicated may attain large dimensions is shown by the fact that

second sirups obtained in the manufacture of Mauritius sugar contain, according to Dr. Icery, from 22 to 43 per cent. of glucose out of 100 total sugars.

“Second. Will the mother liquid drain away completely through the cloth of the filter-presses from the precipitated sugar lime when molasses obtained from cane juice in the usual rough manner is the original material operated upon?

“Here again direct experience is practically wanting. In one experiment which I witnessed, and which was performed on a cane molasses of unknown origin, but believed to be from a refinery, the filtration proceeded without any difficulty. I should remark that solutions of ordinary raw cane sugar can not be filtered through a filter-press, since the gummy matters choke the pores of the cloth, and almost immediately.

“If the above two points can be settled in a favorable manner then the process will be as great a success in a chemical and mechanical sense as it is with beet molasses.”

“Mr. Gill then discusses the commercial conditions requisite for success. But as these conditions are so different in this country from those in London I shall not repeat them. In conclusion he says:

“I can not advise your clients to incur the expense of adopting this process until they have satisfied themselves by experiment that it is as applicable to the molasses of cane sugar as that of the beet.

“I may add that sufficiently extended experiments could be made on a laboratory scale at an expense which would not exceed, say, £40, and which might be less.

“C. HAUGHTON GILL.

“To MESSRS. MATHESON & GRANT,

32 Walbrook, London, E. C.’

*“Not having made any laboratory experiments on the treatment of cane molasses by Steffen’s process, I can not add anything to the above report.

“*Estimate for the establishment of works for the treatment of 10,000 to 15,000 kilograms (22,000 to 33,000 pounds) of molasses per day.*

1 reservoir for molasses, 318 cubic feet capacity, fitted with valves.....	\$182. 50
1 reservoir for water, 212 cubic feet capacity	132. 50
1 measuring tank, with valve.....	112. 50
1 scale, for weighing molasses.....	37. 50
2 mixers, with connections, at \$1,500	3,000. 00
2 automatic measuring apparatus for lime, at \$162.50	325. 00
1 horizontal steam-pump, for the lime saccharate. Cylinder, 12.8 inches diameter; pump, 7.9 inches diameter; stroke, 15.8 inches.....	1,250. 00
1 safety-valve.....	\$37. 50
1 gauge	10. 00
6 filter-presses, at \$675	4,050. 00
6 iron funnels, at \$43.75.....	262. 50
1 double trough, 34.5 feet long.....	105. 00
1 reservoir; capacity, 88.3 cubic feet (for wash water).....	87. 50
1 archimedean screw, 37.4 feet long	440. 00
1 saccharate mill.....	750. 00
1 pump; 2 plungers, 5.9 inches diameter, stroke 7.9 inches, including transmission of power.....	475. 00
1 saccharate pump; 2 plungers, 3.9 inches diameter, stroke, 7.9 inches...	375. 00
1 engine; cylinder, 13.8 inches diameter, stroke, 27.6 inches.....	1,125. 00

* Since this was written experiments have been successfully made in treating molasses with lime for the decomposition of the glucoses preparatory to the use of a saccharate process for the separation of the cane sugar.

1 transmission of power (approximate)	\$725. 00
1 ore-crusher, for lime	537. 50
1 mill, to grind the lime	1, 212. 50
2 elevators (iron), at \$300	600. 00
1 rotary sieve	660. 00
1 hopper, for powdered lime	225. 00
1 aspirator	437.50
Total	17, 155. 00

"The value of the franc in the above estimates is taken at 20 cents.

"In addition to the cost of the machinery a royalty must be paid, depending upon the size of the plant and the length of the working season.

"If the Steffen process is worked in connection with a sugar-house, the royalty is \$7,500 for works having a capacity to treat 22,000 pounds of molasses per day, or \$10,000 if 33,000 pounds are treated. To these sums \$2,500 and \$3,750, respectively, must be added, if the Steffen process is to be employed after the regular campaign of the sugar-house is finished.

"If the plant is to be employed the entire year, only for the extraction of the sugar from molasses obtained by purchase, the royalty is \$10,000 for a daily capacity of 22,000 pounds; \$13,750 for a daily capacity of 33,000 pounds. For larger plants, the royalty is fixed by special contract.

"This process has already been adopted by a number of German sugar-houses, and by eleven this season in Belgium. When I left France in October, the great central sugar-house at Cambrai was about to contract for the installation of the Steffen separation process.

"Plates Nos. 3, 4, 5, and 6 show the disposition of the machinery for working the Steffen process in connection with an ordinary sugar factory.

"NOTE.—Mr. François Sachs, chemist of the Max le Docte Sugar-house, Gembloux, Belgium, has kindly given me the results of his experiments last season with the Steffen process. He says:

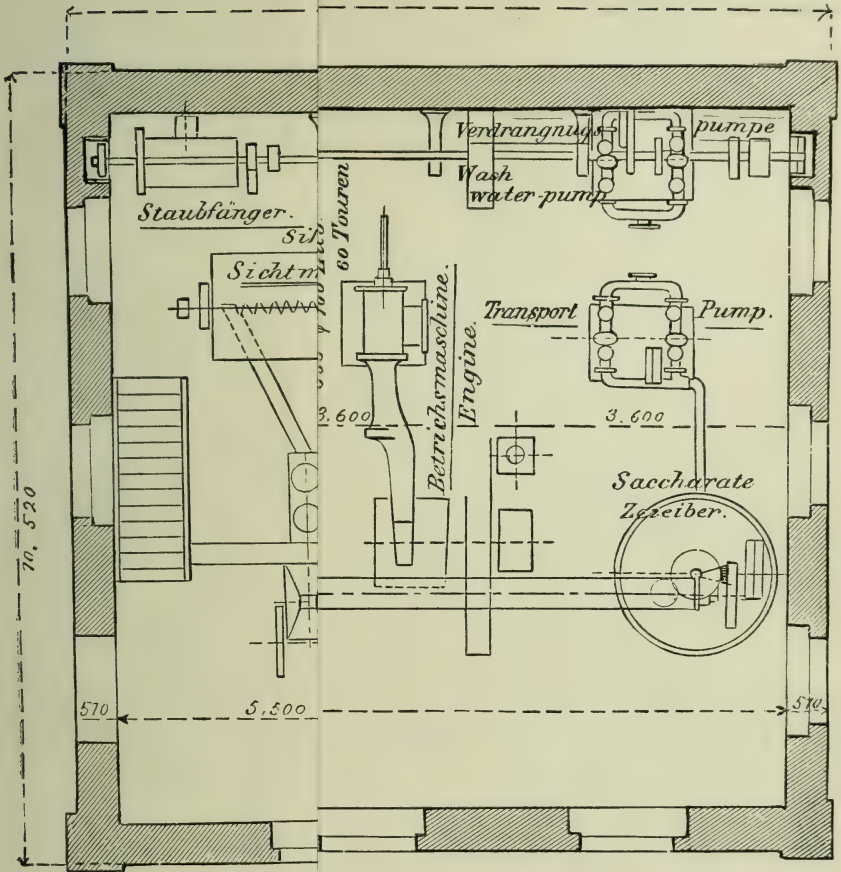
"The separation process for the extraction of the sugar from the molasses yields less sugar in actual practice when molasses alone is treated than was expected. In fact, it is necessary to add sugar in order to obtain a good crystallization.

"Taking 100 kilograms of molasses containing 50 per cent. sugar, we have added 24 kilograms of raw sugar (polarizing 89 to 90 degrees) with the following losses based on the weight of the molasses:

	Per cent.
(1) In the mother liquor * (reheated)	1. 50
(2) In the filter press deposits	3. 27
(3) In the scums from the carbonatation	0. 64
Total	5. 34

"Then 50 kilograms of sugar in the molasses, minus 5.34 loss, leaves 44.66 kilograms in the masse-cuite. The masse-cuite gave 52.52 per cent. first sugar, or 23.45 per cent. of second molasses. There then remained 24.12 per cent. of second molasses

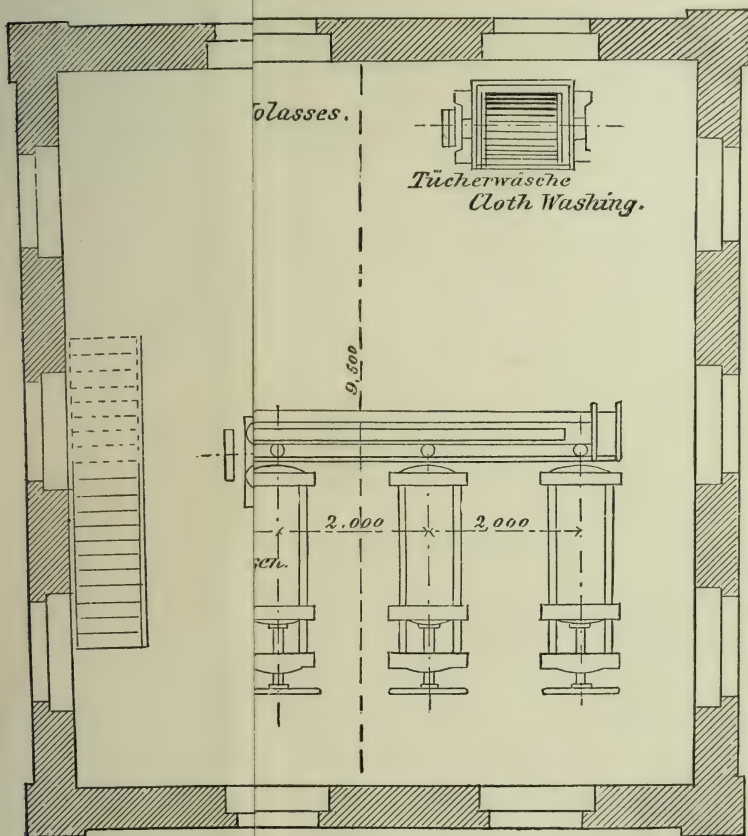
* The mother liquor dissolves a small portion of the saccharate, which is reprecipitated on heating the liquor, and is mostly recovered in the filter presses.



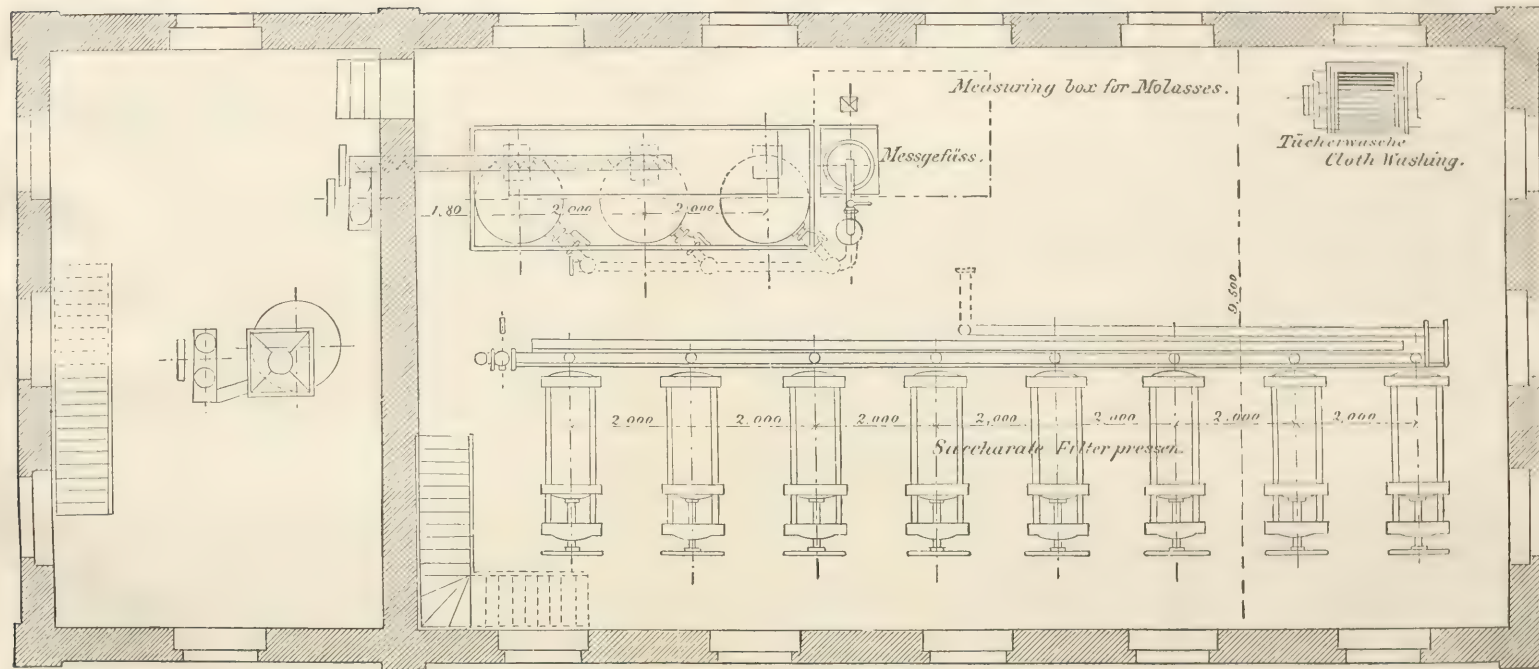


Face page 250.

Scale : 1-100.



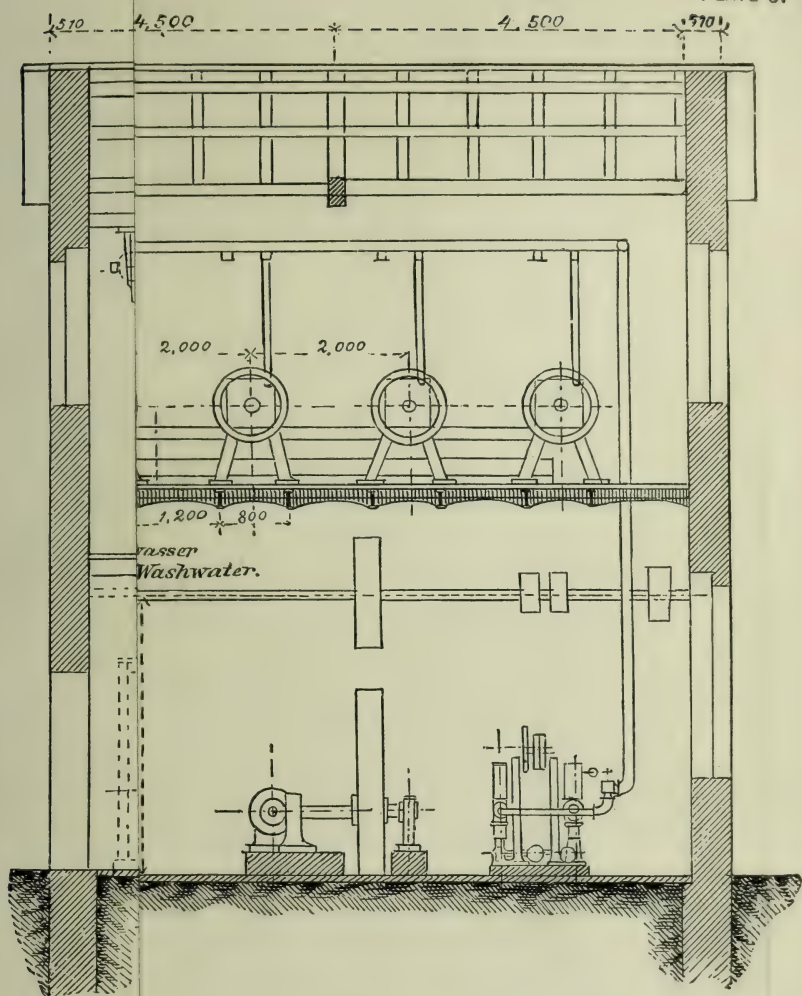
(To follow Plate 3)



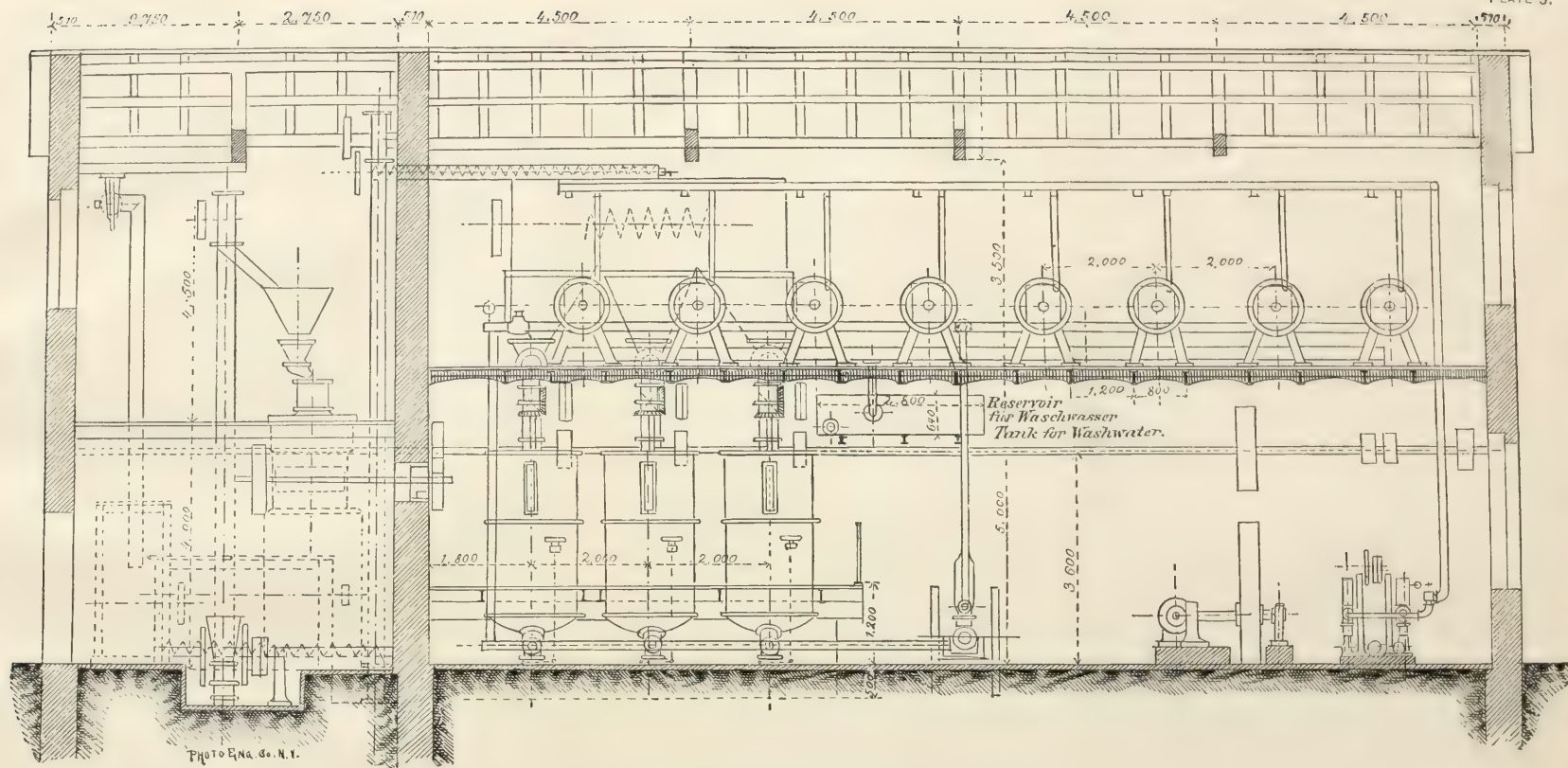
STEFFEN'S PROCESS. PLAN OF SECOND FLOOR.

Scale: 1-100.

(To follow Plate 3.)



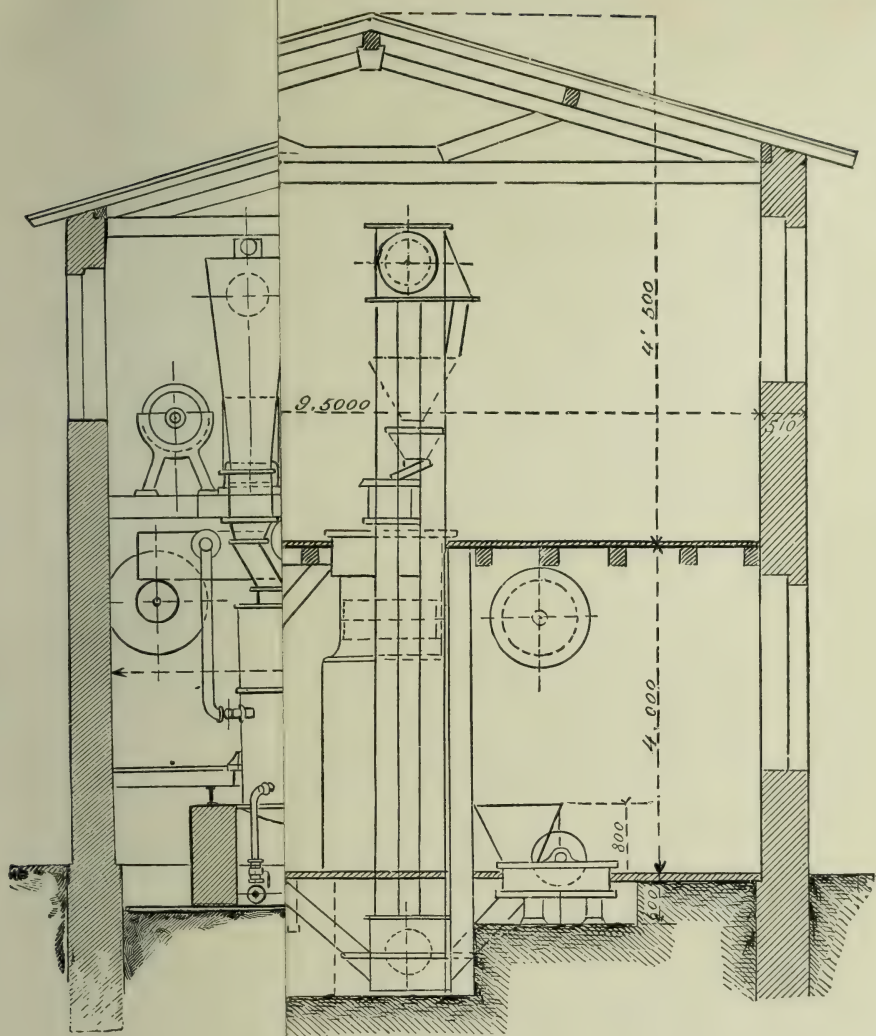
(To f



STEFFEN'S PROCESS. SIDE VIEW, SHOWING DISPOSITION OF MACHINERY.

Scale : 1-100.

(To follow Plate 4)



W'S PROCESS. END VIEW.

(To follow Plate 5.)

(the weight of raw sugar added not being taken into account). The second molasses yielded 25.52 per cent. sugar, or 6.03 per cent. of the molasses originally taken. The total amount of first and second sugars extracted is 23.48, plus 6.03, and equals 29.48 per cent. The proportion of third sugar has not yet been determined."

REPORT ON THE TURKIEWITSCH METHODS OF DIFFUSION.

Turkiewitsch has proved that of all circumstances which insure good desaccharification of the chips, as number of cells composing the battery, temperature, and time of maceration, the last is the most important. To increase this factor, he replaces the long batteries by short ones. For a battery of twelve cells he substitutes two of six cells each. This causes an increase in the amount of beets worked and a heavier and purer juice. It also reduces the sucrose lost in the chips and the consumption of fuel to a minimum. Only slight changes in the connections and pipes are necessary to arrive at the desired result. The battery is operated in the following manner:

(1) The chips are cut so fine that 100 grams represent a length of about 40 millimeters.*

(2) The water should be heated to 30 or 40° R. and should enter the battery under a pressure of from 1 to 1½ atmospheres.

(3) The cells should be filled and emptied as rapidly as possible.

(4) The temperature should always be lower than it is in the old system, and should vary with the kind of beet and the rapidity of work. The last cell (*i. e.*, the one just filled) is not heated and the juice passes from it to the measuring-tank at the same temperature at which it entered. Five is heated as soon as the required amount of juice has been drawn from 6. The cells are to be heated as follows:



(5) The heaters must not contain any water while the cells are being emptied.

(6) The work must be so regulated that while Cell 1 Battery I is being filled with chips, Cell 1 Battery II is emptied and washed. As soon as Cell 1 Battery I has been filled, juice is forced into it from below and Cell 1 Battery II filled with chips. When the latter has been filled, juice is forced into it and then in turn Cell 1 Battery I and Cell 1 Battery II are drawn off.

In actual practice the above method has been found to almost double the time of maceration.

* This corresponds to chips about 2 millimeters wide and 1½ millimeters thick.

In the following tables are some average analyses made at the beet house Raigovad while working according to the new system :

Cells.	Specific gravity.	Degree Brix.	Sucrose.	Purity.	Temperature.
1					o
2	1.0037	1.00	0.44	44.00	50.0
3	1.0015	2.95	1.84	62.30	65.7
4	1.0223	5.65	4.00	70.70	65.7
5	1.0380	9.65	7.16	74.20	65.7
6		11.80	9.80	83.10	50.0

The purity of the normal beet juice was 80.60. The following figures afford a comparison between the two systems :

	Beets ground per day.	Degree Brix, normal juice.	Sucrose in exhausted chips (95.5 per cent. juice).	Sucrose in waste water.	Degree Brix diffusion juice.
	<i>Kilos.</i>			<i>Per cent.</i>	
One battery of twelve cells.....	291,854	15.10	0.31×95.5 100	134×0.08	10.30
Two batteries of six cells each	352,433	15.40	0.30×95.5 100	119×0.08	11.60

Seventy-five per cent. of milled bagasse were obtained. The waste water showed 0.2° Brix; the juice from the exhausted chips 0.6° The beets contained 95 per cent. juice.

The dilution in both methods is calculated as follows :

A. Long battery.

$$\begin{aligned}
 75 \times 0.6\% \times 95.5\% &= 0.429 \\
 134 \times 0.2\% &= 0.268 \\
 &\hline
 &0.697 \\
 15.1 \times 0.95 &= 14.34 \\
 &\hline
 &13.64 \text{ solids extracted.} \\
 \frac{13.64 \times 100}{10.3} &= 132 \text{ juice per 100 beets.}
 \end{aligned}$$

B. Short battery.

$$\begin{aligned}
 75 \times 0.6\% \times 95.5\% &= 0.429 \\
 119 \times 0.2\% &= 0.238 \\
 &\hline
 &0.667 \\
 15.4 \times 0.95 &= 14.60 \\
 &\hline
 &13.93 \times 100 \\
 &\hline
 &11.6 = 120 \text{ juice per 100 beets.}
 \end{aligned}$$

During the last season the beet house Mirowoka ran for five weeks according to the old and the remaining thirty-six days according to the new system. The following table makes the advantages of the new system manifest :

System.	No. of days run.	Average daily run.	Normal juice.			Dilution per 100 beets.	Diffusion juice.			Sucrose lost.	Time of maceration in cell.	Fuel per cent. consumed beets.	Fuel in 24 hours per hl. cell content.
			Brix.	Sucrose.	Purity.		Brix.	Sucrose.	Purity.				
Long battery.	36	<i>Kilos.</i> 275,600	<i>Per ct.</i> 16.41	12.72	77.43	166.	<i>Per ct.</i> 9.33	7.32	78.46	0.523	50.	<i>Per ct.</i> 12.98	<i>Kilos.</i> 1338
Short battery.	86	324,300	15.61	12.00	76.85	132.5	11.06	8.71	78.89	0.499	46.2	11.82	1504

It becomes apparent that the above house has increased (1) the daily amount ground by 17.4 per cent., (2) the diffusion juice by 24.33 per cent., (3) and has lessened the (3) volume of juice by 32.6, (4) consumption of fuel by 1.16 per cent., (5) while the juice has a higher purity and (6) the loss of sucrose has been reduced. We can safely assume that the new system increases the daily capacity of the house by 10 per cent.*

GENERAL PLAN OF SUGAR-HOUSE.

For the information of the many persons who have written for general intelligence in regard to a beet-sugar house, Mr. G. L. Spencer has prepared at my request the following plan for such a building. (Plates 7, 8, 9.)

It would be unnecessary in this place to give the general working details of such a building, since those who propose to build such houses would desire to modify them in so many cases that such a general plan in detail would be undesirable. What is given, therefore, is merely for the purpose of illustrating the principles upon which a beet-sugar factory should be built and the general arrangement and proportion of its various parts :

Ground floor. (Plate 7.)

1. Warehouse for sugars.
2. Packing room for sugars.
3. Space for eight centrifugals.
4. Centrifugal engine.
5. Hot room for low-grade sugars.
6. Elevator.
- 7, 8, 9. Vacuum pumps.
10. Carbonic-acid-gas pump.
11. Diffusion battery.
12. Hydraulic beet transporter.
13. Beet-washing apparatus.

*Sucrerie belge, No. 3, October 1, 1888.

14. Beet-elevator.
15. Driving-engine for cutters, etc.
16. Bone-black filters.
17. Room for treatment of bone-black preparatory to revivification.
18. Space for bone-black kiln.
19. Chimney.
20. Boiler-house and pump-room.
21. Lime-kiln.
22. Room for slaking lime.

Second floor. (Plate 8.)

1. Space for sugar-bins.
2. Room for first sugars.
3. Hot room for second sugars, etc.
4. Elevator.
5. Carbonatation pans.
6. Triple effect.
7. Bone-black filters.
8. Diffusion battery.
9. Pulp-room.
10. Chutes for use in removing pulps.
11. Beet elevator.
12. Space for filter presses.
13. Laboratory.

Third floor. (Plate 9.)

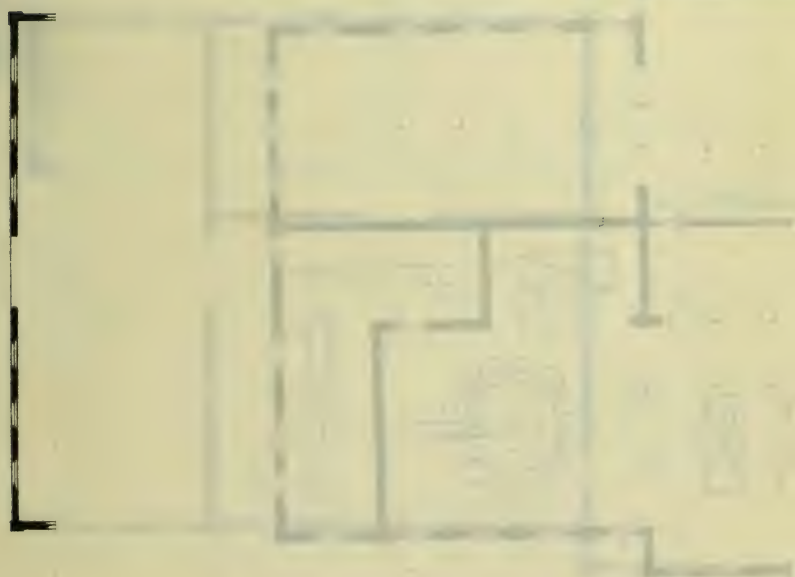
1. The vacuum pans discharging into wagons, etc., in the hot room as indicated by dotted lines from the pans.

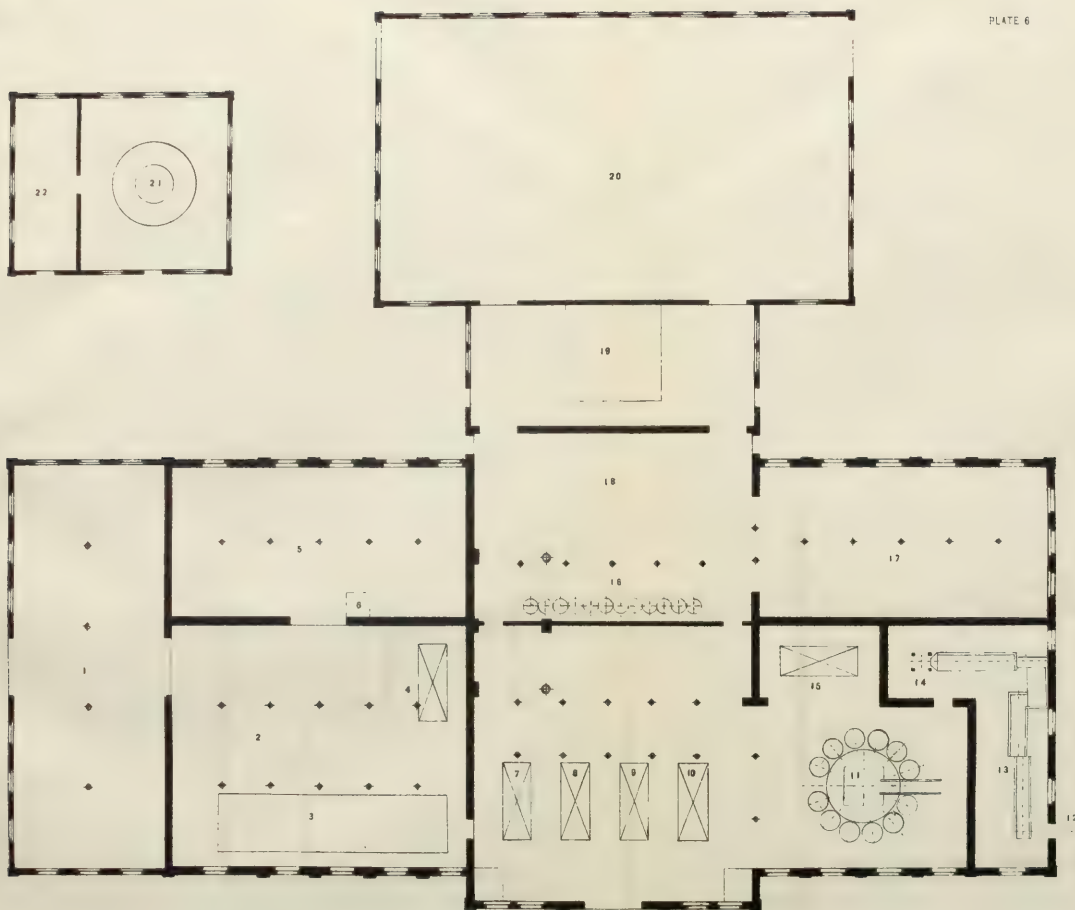
The dotted lines (continuous with the main walls) indicate the location of the attics, which are high enough to accommodate projecting portions of the cutter and the pulp presses.

The general arrangement of a diffusion battery is shown in Plate 10, one of a sugar factory in Plate 11. These plates are taken from Bulletin No. 8, and are printed from plates furnished by the Fives-Lille Company, No. 84 Rue Coumartin, Paris, France.

COST.

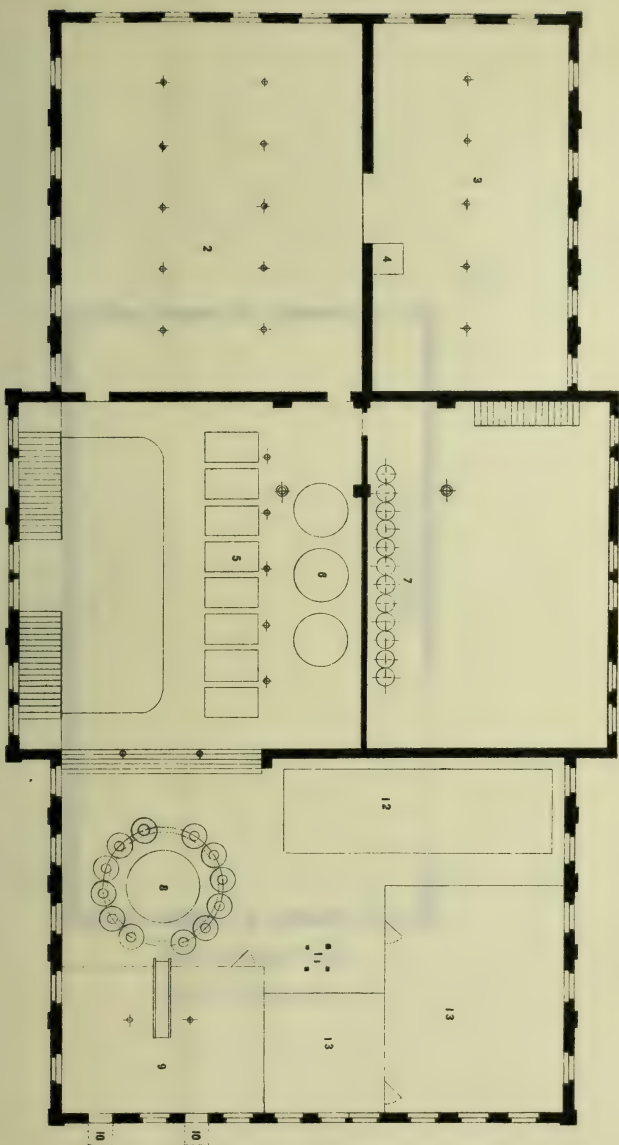
The cost of a beet-sugar factory depends on so many conditions that it will be impracticable to give anything more than a rough estimate of it. Much depends upon the character of the building itself, and this, for various reasons, should be made fire-proof, thus entailing the construction of a building of considerable cost. In regard to both the building and machinery, the total cost will depend largely upon the capacity of the house; the cost, however, does not increase in the same ratio as the capacity. In other words, it may be stated that the cost of a beet-sugar factory capable of working 400 tons of beets per day would not be double the cost of one working 200 tons. A beet-sugar house based on an estimated capacity of 300 tons per day would probably be more in keeping with the character of the houses which are to be built





PLAN OF FIRST FLOOR.

- Scale $\frac{1}{4}$ in. to 1 ft. -



PLAN OF SECOND FLOOR.

— Scale $\frac{1}{32}$ in to 1 ft. —



Figure 1. 1991

Figure 1. 1991

in this country for some time than any other. With a proper fire-proof building, and the best and latest machinery, such a factory would cost, ready for work, from \$150,000 to \$200,000. Factories, of course, can be built at a much less cost than this, but doubtless at the sacrifice of efficiency in some of its parts, so that true economy would advocate the construction of a high-priced factory of the best workmanship and of the most approved modern style.

Local considerations may also affect the cost of a factory, as distance of transportation of the machinery, nearness of iron and machine works, cost of land, etc. The Department has received many letters from persons conveying the impression that they have an idea that a beet-sugar factory can be built for a few thousand dollars, whereas it is seen from a general study of the problem itself that such a small outlay would be totally inadequate to secure a factory suitable for the work to be done.

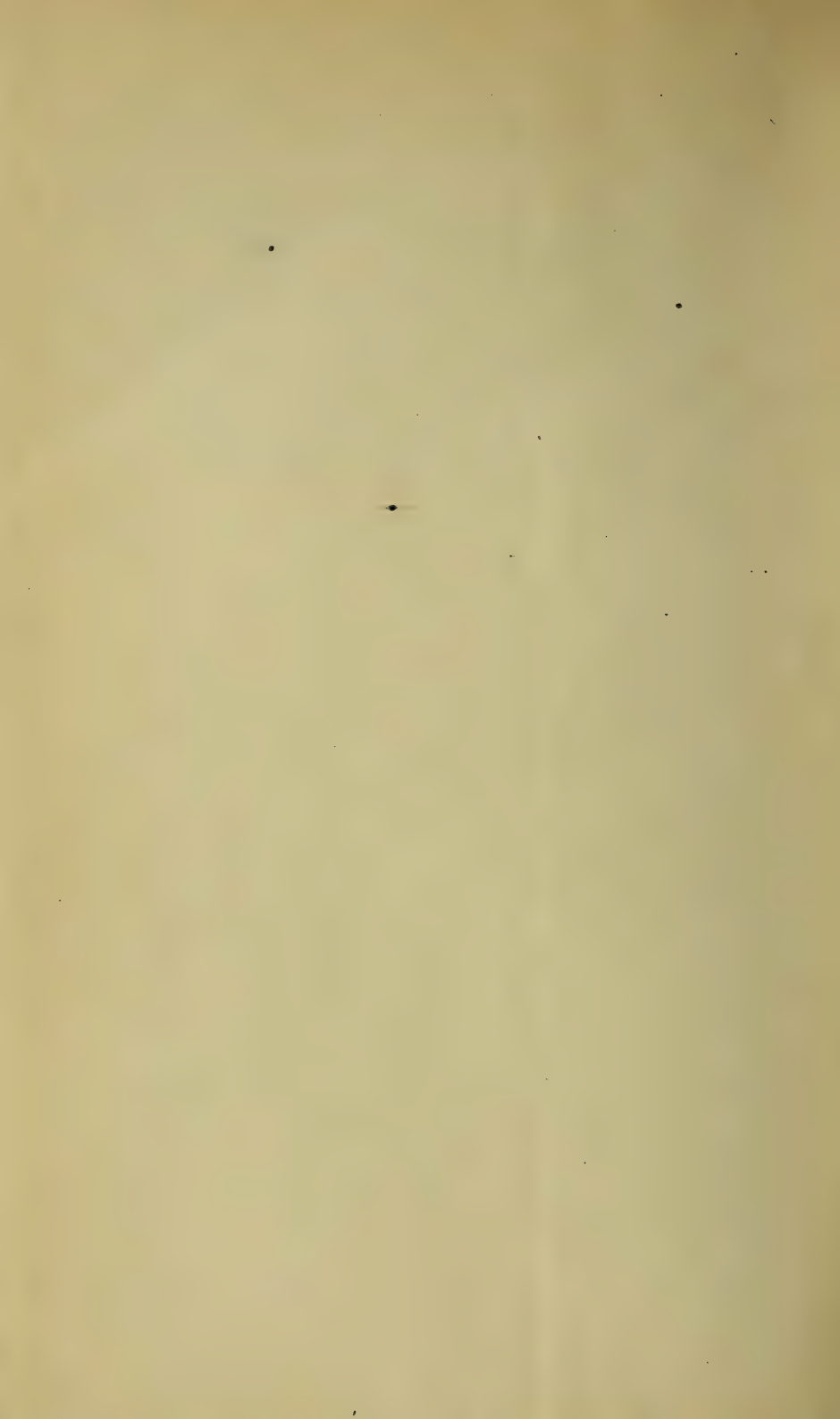
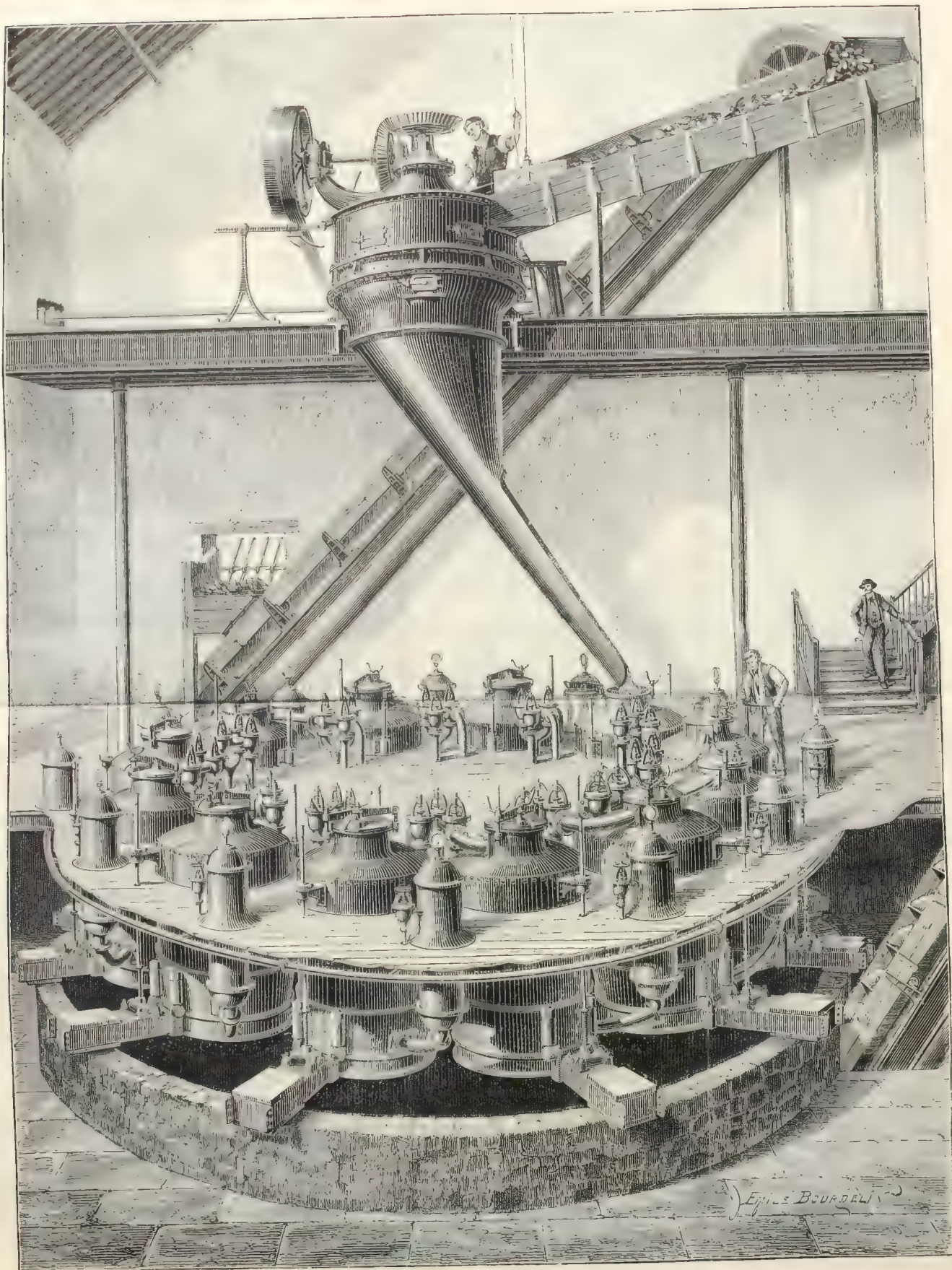
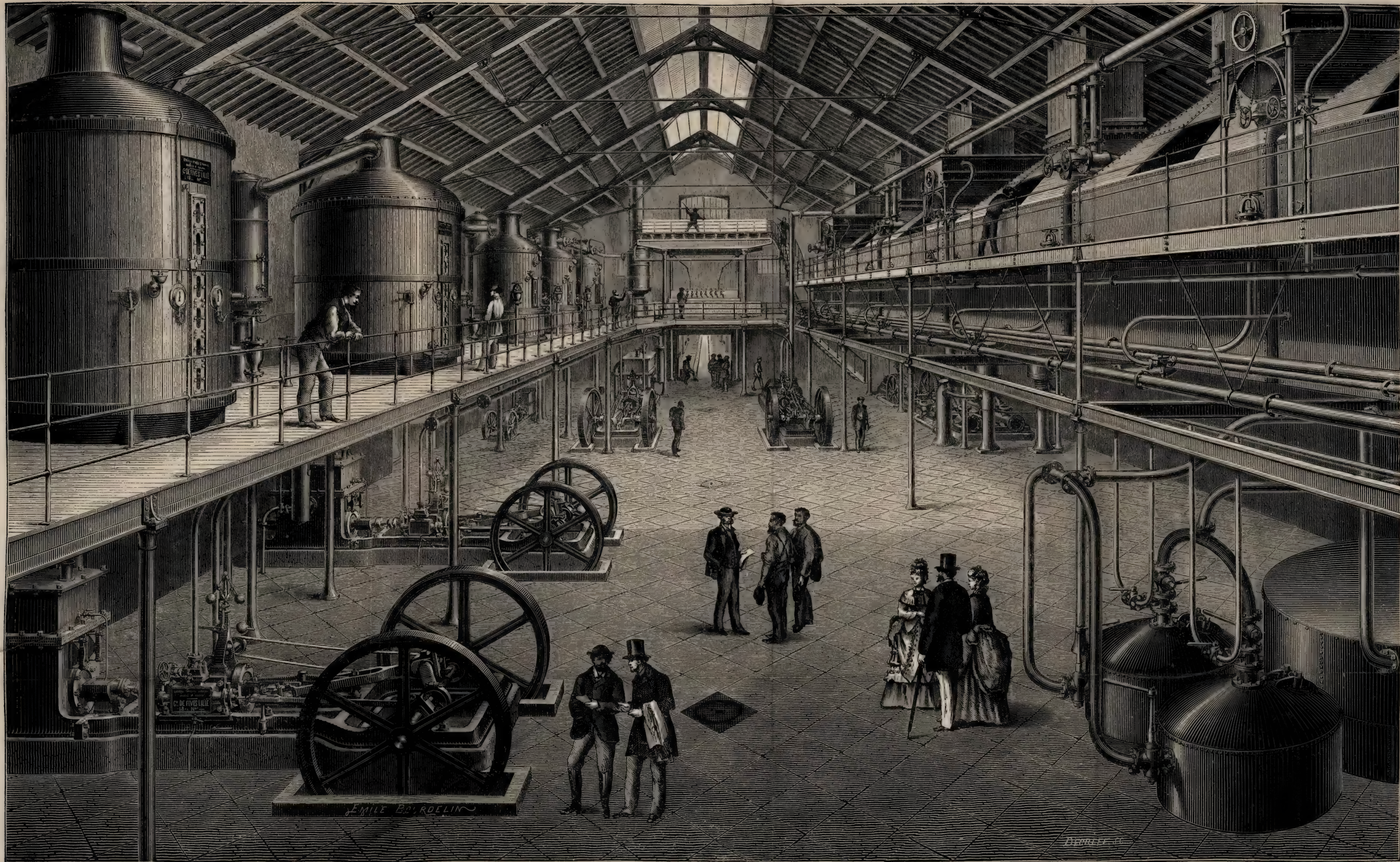


PLATE 10.





INDEX.

A.

	Page.
Achard, letter of, in <i>Moniteur</i>	12
researches of	10
Acreage in beet-seed culture	78
Air in beets	77
Alvarado, early history of the beet-sugar industry at	35-37
experiments at	33
manufacturing work at	209
Area in the United States suitable to sugar-beet culture	169, 177
of soil suitable for culture of beets in California	118
Ashes of beets, composition of	128

B.

Babrinsky, rules of, in regard to silos in Russia	101
Bajac harvester	94, 95
Barruel, method of extracting sugar of	22
Becker, Dr. G. F., observations of	114, 115
Beet, green top	50
gray top	51
imperial	49
molasses, composition of	246
pink top	50
root, structure of	51
seed amelioration	73
method of Peligot and Leplay	74
Pellet	74
preparation of, for planting	139, 140
preservation of	46
production of, at Carlier	76
sugar factory, establishment of, in Prussia	26
industry, extension of, in Germany	25
in Europe, total production of, during past four years	40
France in 1810	19
the Northwest, report of Mr. J. D. Fredericksen	44, 218
manufacture, attempts at	7, 8
production of, in California, 1870, 1873	33
Vilmorin improved	51
White Silesian	49
Beets, varieties of	70
grown in France	47
Bohemia, soil and climate of	122
Brabant sugar-beet	69, 72
Bulletin, object of	5, 6
Burr, Mr. E. C., letter of	85

C.

	Page.
California beets, analyses of, in laboratory	202
experiments in	35, 192-194
soils of, adapted to beet culture	107
southern, sugar-beet culture in	204
Calorisators, use of	235
Camburgh sugar factory, description of	238
Canada, beet-sugar industry in	211
experiments in	34
factories in	212
Cane and beet sugar, comparison of	40
statistics of production of	41
in Russia	41
sugar, production of, in Java	41
Carbonation, process of	233
Cellars, preservation of beets in, according to Walkhoff	102
Champion and Pellet, observations of	47, 48, 52, 55
on the relation between the weight of organic matters and ash	134, 135
Chaptal, report of	22
Chatsworth, Illinois, beet-sugar factory at	37
experiments at	32
Chemistry and physiology of the beet	161-163
Child, Mr. David Lee, experiments of	31
Chino Ranch, experiments at	207
Climate of California, description of	109, 110
Washington	121
Continuous diffusion battery	229
Corenwinder and Contamine, experiments of	48
Crops preceding beets	137
Cultivation, conditions of	67
directions for	144
implements for	80-85
method of, used at Alvarado	85, 86
methods used in Bohemia	87-92

D.

Decaisne, M., studies of, in structure of beet root	51
Decombrecque, M., method of, in selecting seed	63
Deherain, Professor, experiments of	47
Delaware, experiments in	35
Demiatte, M., method of, in selecting "mothers"	62
Department of Agriculture, analyses of beets by	210, 211
Development of the beet	159-161
conditions of	137
Diffusion battery, arrangement of	228
Directions for preparing soil	137-139
Distance between rows, influence of	142, 143
of beets in row	79, 87
rows	79
Drainage, importance of	136
Drouyn de l'Huys, M., observations of, on the effect of nitrogen	133
Dubrunfaut, observations of, on the cost of production	30
production of beet seed	59

	Page.
Dyer, Mr. E. H., data from	197-201
letters from	203

E.

Eckenbrecher and Maercker, studies of, of typical forms of beets	163-168
England, beet-sugar industry in	212, 213
Evaporation, apparatus for	232
Extraction of the juices, apparatus for	227

F.

Farmyard manure, application of	78
Fertilizers, best method of applying	136
Dr. Stammer's observations on	147, 148
Financial disaster, avoidance of	6
danger of	6
Fond du Lac, Wis., experiments at	32
Fredericksen, Mr. J. D., report of, on beet sugar in the Northwest	213-219

G.

Georges, M., observations of, on the effect of nitrogen	133
Gill, Mr. C. Haughton, report of, on Steffen's process	248, 249
Girard, Prof. Aime, studies of, in beet development	159

H.

Harvest and preservation of beets	99, 100
Harvesting beets	93
apparatus for	94
Henry, Prof. W. A., letter from, in regard to Chatsworth	37
report of	178-181
Herzfeld, observations of, on nitrogenous manures	151, 152
Hilgard, Prof. E. W., analyses of soils by	108, 109, 116-118
description of climate in California by	109
report of	107
Hinze, Mr. Fred, experiments of	192
Howes, commercial agent, observations of, on manuring in Bohemia	154-158
report of	87
Huston, Prof. H. A., analyses by	178

I.

Imperial beet-sugar factories, establishment of	24
Indiana, experiments in	177
Inquiries relating to sugar-beets	5
Introduction	5-8
Iowa, experiments in	181

J.

Joulie, Professor, observations of	53, 54, 56
on effect of nitrogen	132
Juice, treatment of	233

K.

Kansas, experiments in	190
Kedzie, Dr. R. C., analyses by	178

	Page.
Klein-Wanzleben sugar-beet.....	69, 71
Koester, Mr., observations of, on drying pulps.....	222, 223

L.

Labor, cheapness of.....	7
Lawes and Gilbert, observations of, on the effect of fertilizers.....	134
Legrand, M., exhibition of, at the Paris Exposition.....	75
Lemaire, system of selecting beets of.....	77

M.

Maercker, Professor, experiments of, in feeding pulps.....	224-226
observations of, on the effect of nitrogen.....	133
Maine, experiments in.....	34
Manufacture of sugar, outline of.....	226, 227
Manures, influence of, on yield and richness of sugar.....	130, 131
Manuring, methods of, in Bohemia.....	154
Margraff, discoveries of.....	9
Massachusetts, experiments in.....	34
Massecuite, treatment of.....	240
McMurtrie, Dr. William, observations of, on soil and climate.....	124-128
special report of.....	9
Meeker, Mr. E., letter from.....	119-121
Meteorological conditions.....	169
Signal Service tables on.....	170-175
studies of Dr. William McMurtrie on.....	169-175, 176
Meyer & Buettner, apparatus of, for drying sliced beets.....	213
Michigan, experiments in.....	178
Mineral constituents removed by crop.....	128, 129
Molasses, extraction of sugar from.....	244
Montalivet, letter of.....	17
report of, in Moniteur.....	16
Mothers, selection of.....	43
by Dippe.....	44, 45
Proskowetz.....	46
Rabbethge.....	45

N.

Nadeau, Mr., experiments of.....	204-206
Napoleon I., decree of.....	16, 18
establishing beet-sugar factories in schools.....	21
fall of, effect of, on beet-sugar industry.....	28
Nebraska, experiments in.....	183-185
Neck of the beet, removal of.....	98, 99
New Jersey, experiments in.....	34
Nicholson & Lloyd, Professors, analyses by.....	184
Nitrate of soda, fertilizing with.....	152
Nitrogen as nitrates, effect of.....	132
Nitrogenous manures, influence of, on the quality of the beet.....	151

O.

Oregon, sugar beet in.....	119
Organic matters and ash, relation of.....	134, 135
Oxnard, Mr. H. T., experiments of, at Grand Island, Nebr.....	184

P.

	Page.
Pagnoul, observations of, on the effects of nitrogen	132
Patrick, Prof. G. E., analyses by	182, 183
Pellet, M., observations of, on the influence of fertilizers	134
Per cent. sugar in sugar-beets	10
Peret, M., continuous diffuser of	229-232
Petermann, Dr. A., contribution of, to the chemistry and physiology of the beet	161
observations of, on nitrate of soda	152-163
Phosphate slag, experiments with	152
Plowing, depth of	78
Potash, best method of applying	149-151
Potassic and lime salts, action of	74
Prefatory note	3
Preservation of beets	145
best temperature for	145
depth of covering in	146
Production of seed	41
Proskowetz, Dr. E. V., experiments of, with nitrogenous manures	153
phosphate slag	152, 153
Pulps, drying of	222, 223
feeding experiments with	224-226
preservation of	221, 222
silos for	220
use and treatment of	220

R.

Rain-fall, amount of, necessary	176, 177
in California	111-114
Reynolds, Mr. John P., letter from, in regard to Chatsworth, Ill	38

S.

Sachs, Mr. Francois, experiments of, on the Steffen process	250
Sagnier, M., observations of	76
Sanborn, Mr. T. F., analyses by	191, 192
Saturation, process of	233
Schack-Sommer, Dr., experiments of	212, 213
School for manufacture of beet sugar, establishment of, in France	23
Seed, beet, production of	41
Seeding	79
by hand	79
drill	79
time of	141
Separation process, chemistry of	244
Shepard, Mr. James H., analyses by	190
Silos in cellars, illustrations of	103, 104
Size and shape of beet, influence of	75
observations of Desprez upon	75
Soaking seed, solution for	140
Soil and climate of Bohemia	123-124
character of, suitable for sugar-beets	105
chemical analyses of	108, 109, 116-118
constituents of	105, 106
nitrogen in	105

	Page.
Soil, observations of Stammer on	106, 107
of Washington	121
Soquel factory, fate of	33
South Dakota, experiments in	185-189
Spencer, Mr. G. L., plans of, for a sugar factory	253, 254
report of, in Bulletin No. 5.	227-250
Stable manure, amount of, necessary	130
composition of	129
Stammer, Dr. Karl, observations of, on fertilizers	147
work of, on sugar-beet	99
Statistics of the beet-sugar industry	39
in Germany	39
Steffen process	248
Stoebritz sugar factory, description of	234
Subsoiling	78
Sugar beet, culture area of	7
early development of, in Germany	12
improvement of	66
industry, historical	9
progress of, in America	31
report of commission on	11
seed, methods of procuring the best	68
factory, cost of	254, 255
general plan of	253
Summers, hot, in Kansas	7

T.

Temperature and rain-fall, relative importance of	177
Turkiewitsch, diffusion battery of	251-253
Typical forms of sugar-beets	163

V.

Vilmorin-Andrieux & Co., production of beet seed by	41
Vilmorin, M., early recommendations of	74
experiments of	61
M. Henri, description by, of varieties of beets in France	64
experiments of	62
white improved sugar-beet	70
Violette, M., observations of	53-55

W.

Walkhoff, Professor, observations of, on the production of beet seed	58
Ware, Mr. Lewis S., description of methods of harvesting, by	95, 98
Washington, climate of	121
soil of	121
sugar-beet in	119
Watsonville, Cal., experiments at	209
factory, analyses of beets at	208
Weight of beets	67
Wet autumn, influence of	170
White French rich sugar beet	73
improved Vilmorin beet	42
Wisconsin, experiments in	178

U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF CHEMISTRY

BULLETIN

No. 28

PROCEEDINGS

OF THE

SEVENTH ANNUAL CONVENTION

OF THE

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS

HELD AT

THE U. S. NATIONAL MUSEUM AUGUST 28, 29, AND 30, 1890

METHODS OF ANALYSIS OF COMMERCIAL FERTILIZERS,
FOODS AND FEEDING STUFFS, DAIRY PRODUCTS,
FERMENTED LIQUORS, AND SUGARS

EDITED BY

HARVEY W. WILEY

SECRETARY OF THE ASSOCIATION

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON

GOVERNMENT PRINTING OFFICE

1890

U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF CHEMISTRY

BULLETIN

No. 28

PROCEEDINGS

OF THE

SEVENTH ANNUAL CONVENTION

OF THE

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS

HELD AT

THE U. S. NATIONAL MUSEUM AUGUST 28, 29, AND 30, 1890

METHODS OF ANALYSIS OF COMMERCIAL FERTILIZERS,
FOODS AND FEEDING STUFFS, DAIRY PRODUCTS,
FERMENTED LIQUORS, AND SUGARS

EDITED BY

HARVEY W. WILEY

SECRETARY OF THE ASSOCIATION

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON

GOVERNMENT PRINTING OFFICE

1890

Compliments of
J M Rusk
Secretary of Agriculture

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., November 26, 1890.

SIR: I have the honor to submit the report of the Proceedings of the Seventh Annual Convention of the Association of Official Agricultural Chemists, with the recommendation that it be published as heretofore as a bulletin of the Chemical Division of the Department.

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary of Agriculture.

PROCEEDINGS OF THE SEVENTH ANNUAL CONVENTION OF THE
ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS,
HELD AT WASHINGTON, AUGUST 28, 29, AND 30, 1890.

FIRST DAY.

MORNING SESSION, THURSDAY.

In accordance with the call of the executive committee, the association met in the lecture hall of the U. S. National Museum at 10 o'clock, the president, Mr. M. A. Scovell, in the chair.

The following members and "others interested in the objects of the association" were present:

Hon. Edwin Willits, Assistant Secretary of Agriculture.

The president, Mr. M. A. Scovell, director of the Kentucky Agricultural Experiment Station, Lexington, Ky.

The vice-president, Mr. G. C. Caldwell, chemist of the New York Agricultural Experiment Station, Ithaca, N. Y.

The secretary, Mr. H. W. Wiley, chief chemist, U. S. Department of Agriculture.

Of the executive committee, Mr. J. A. Myers, of Morgantown, W. Va.; and the following members and participants:

Allen, E. W., Washington, D. C.
Alvord, Henry E., Agricultural College,
Md.
Anderson, J. T., Auburn, Ala.
Atwater, W. O., Washington, D. C.
Battle, H. B., Raleigh, N. C.
Bowman, Walker, Blacksburg, Va.
Burney, W. B., Columbia, S. C.
Carpenter, F. B., Raleigh, N. C.
Cooke, W. W., Burlington, Vt.
Crampton, C. A., Washington, D. C.
Dancy, F. B., Raleigh, N. C.
De Ghequier, A., Washington, D. C.
Edson, Hubert, Patterson, La.
Farrington, Edward H., Champaign, Ill.
Frear, William, State College, Pa.
Gaines, Richard H., Richmond, Va.

Gascoyne, W. J., Baltimore, Md.
Gibson, Charles B., Chicago, Ill.
Harris, A. W., Washington, D. C.
Herff, B. v., Washington, D. C.
Horton, Horace E. L., Washington, D. C.
Huston, H. A., Lafayette, Ind.
Kedzie, R. C., Lansing, Mich.
Knorr, Aug. E., Washington, D. C.
Lupton, N. T., Auburn, Ala.
McBryde, J. B., Columbia, S. C.
McDonnell, H. B., State College, Pa.
Nicholson, H. H., Lincoln, Nebr.
Parsons, Charles L., Hanover, N. H.
Patterson, H. J., Agricultural College, Md.
Patterson, L. G., Agricultural College,
Miss.
Penny, C. L., Newark, Del.

Richards, Edgar, Washington, D. C.
 Richardson, Clifford, Washington, D. C.
 Robinson, Norman, Tallahassee, Fla.
 Ross, B. B., Baton Rouge, La.
 Schweinitz, E. A. v., Washington, D. C.
 Shiver, Frank S., Columbia, S. C.
 Street, J. P., New Brunswick, N. J.
 Stubbs, William C., Audubon Park, New Orleans, La.

Terne, Bruno, Philadelphia, Pa.
 Trescott, T. C., Washington, D. C.
 Van Slyke, L. L., Geneva, N. Y.
 Voorhees, E. B., New Brunswick, N. J.
 Whitney, Milton, Columbia, S. C.
 Williams, William J., Philadelphia, Pa.
 Woods, Charles D., Middletown, Conn.

ADDRESS OF MR. M. A. SCOVELL, PRESIDENT

The president called the convention to order, and spoke as follows:

GENTLEMEN OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS: We begin to-day the seventh annual meeting of this association. In opening the meeting I take pleasure and feel justified in congratulating you upon the progress made by the association in this brief period, and the manifest influence it is exerting in making comparable the results in the chemical analyses of fertilizers and agricultural products in general.

The proceedings of this association have always been carefully edited and only what we considered valuable put into our publications. Its progress, therefore, is shown in the statement that the proceedings of the second annual convention covered fifty pages of printed matter, the third sixty, the fourth eighty, the fifth ninety-six, and the sixth two hundred and thirty-six pages.

When the association was first organized the primary object of it, as stated in the constitution, was to secure uniformity and accuracy in the methods and results of fertilizer analysis. At that time it was considered a gigantic undertaking, and it was not considered feasible to take up other subjects of investigation. The first two or three years were taken up with potash and phosphoric acid alone. As late as 1885 we find Wiley describing the use of the Gooch crucible in potash determinations. We found that a uniform method of determining nitrogen was so great a task that up to 1886 the committee on nitrogen had no report to make, but now we have methods not only for determining nitrogen, potash, and phosphoric acid, but we have been enabled to expand by taking up the subjects of cattle foods, the analysis of sugar, and dairy products, and have set a committee to work on the methods of analysis of fermented liquors.

This rapid progress has been accomplished by being thoroughly organized and having so many active workers in our ranks, thus being enabled to test methods by many actual trials in a single year and further to note the error of personal influence which is ever present and which should have its bearing in the adoption of methods. I think its greatest influence has been felt by reason of our careful selection of methods and still more careful changes in them, and for always demanding the results, not only of the individual, but of the several

members, to substantiate the accuracy of any method or any change of method before adoption. That our methods are adopted by agricultural chemists generally in this country is seen by all, almost all published results stating that the methods used were those adopted by the Association of Official Agricultural Chemists. Abroad we have found our methods published in several journals, and they have been incorporated in Griffith's book on Commercial Fertilizers, published in England.

During the meeting of the Association of Agricultural Colleges and Experiment Stations last November it was recommended that all analyses made at experiment stations be made by the methods adopted by the Association of Official Agricultural Chemists, and that if any chemist saw reason for following other methods it should be distinctly so stated wherever the results were published.

That such an organization, probably the strongest in the country, should adopt such a resolution shows the influence exerted by this association.

Thus it will be seen that our methods have been recommended to be adopted by over forty stations in this country. The analytical work to be done by these stations is simply enormous, and as these results as they will accumulate and multiply will either assist in greatly advancing our knowledge of agricultural science or retarding it, we should feel the responsibility resting upon us. This should lead us to carefully consider all changes in methods, and yet be ever ready to make changes where we find weak points in them, wherever we can simplify the work, and wherever we can shorten it with due regard to accuracy. To this end I desire to call the attention of the association to a few things which I believe require careful consideration by you.

RECOMMENDATIONS.

First is the matter of a standard acid solution. On the accuracy of determining this depends the results of our nitrogen, whether in commercial fertilizers, cattle foods, or other products. This point heretofore has not been neglected by the association, as we have adopted four different ways of determining the strength of the acid solution. But I am decidedly of the opinion that in many instances the variation of our results is not so much the fault of the methods in determining nitrogen as in the varying strength of the acid used by the different analysts. My attention was called to this last year by a comparison of the acids used by the various chemists who reported on nitrogen determinations. This year further investigations have led me to have made a series of trials to test the strength of the acids by the various methods now in use by the association. Prof. A. M. Peter carefully determined our standard acid by the various ways with the following results:

By precipitating the chlorine and weighing the silver chloride according to Crooke's method, he found that one liter of one-tenth normal

ammonia, which should contain 1.400 grams nitrogen if the standard were exactly one-tenth normal, did actually contain 1.406 grams nitrogen. This result was obtained from the mean of three closely agreeing determinations.

The potassium tetra-oxalate method gave 1.418 grams nitrogen to the liter and by distilling ammonium chloride 1.423 grams nitrogen were obtained.

Upon the distillation of ammonio-ferrous sulphate 1.414 grams, and by the distillation of ammonium iron alum 1.416 grams were obtained.

At first sight these results would seem close enough for practical use. But let us see the results of the various factors on No. 1 nitrogen samples sent out this year; .7 gram used. It will be seen from these results that the standard acid alone, if made by the various methods, is responsible for the discrepancy of .12 of 1 per cent. It seems to me, therefore, that it is again worth while to call the attention of the association to the preparation of a standard acid and to take steps by means of which the standard acids of the various laboratories may become absolutely comparable.

It is time that the ammonium citrate-soluble phosphoric acid should receive serious consideration by this association. The method as it stands is open to many objections. It is in regard to this subject that our veracity as chemists is often questioned, and when this is done we can say but little in our own behalf for a method that on the slightest provocation will give results in duplicate varying from 1 to 3 per cent.

A few minutes under or over the regulation half hour will often play havoc with us. A thermometer whose veracity is not up to the standard will often cause us much anxiety when we come to compare our results. A slight acid or alkaline tendency of the solution, too delicate perhaps to be noticed by litmus or coralline, is no doubt the cause of many of the attacks of our fertilizer friends. There is now beginning to be used in this country a considerable amount of hydrated aluminum phosphate in our commercial fertilizers. This seems to be much more soluble in a slightly alkaline solution of ammonium citrate than in a slightly acid solution.

Dr. Gibson, of Chicago, sends me some very interesting results which relate directly to this question. The continuous dissolving action of neutral ammonium citrate solution is well known. His experiments would tend to show that when the solution was slightly alkaline the dissolving action ceased at a given point, supposed by Dr. Gibson to be reached whenever the available P_2O_5 is dissolved. His results on South Carolina rock, dissolved by ammonium citrate solution, by the official method, gave 1.01, .90, .83; an average of .913. By the ammonium citrate solution, slightly alkaline, .75, .73, .76; mean .746. By digesting for one hour, official method, 1.85, 1.83, 1.86; mean, 1.846. Slightly alkaline ammonium citrate solution, .787, .740, .760; mean, .761.

On aluminic phosphate by official method 19.80, 19.90, 19.63 ; mean 19.77. Ammonium citrate solution, slightly alkaline, 31.24, 33.44, 30.31, mean 31.66. By digesting 1 gram for one hour instead of one-half hour, as required by the official method, the results were: in neutral citrate solution, 31.48, 32.11, 30.59, mean 31.39; in slightly alkaline citrate solution, 34.68, 34.79, 34.73; mean 34.73; thus indicating by the remarkable agreeing results with the alkaline solution that the dissolving action had ceased, while a variation of 2 per cent in the neutral solution would indicate the opposite.

Since receiving Dr. Gibson's results we have started some experiments on a similar line. They are not yet completed, but some of the results are out. On the same sample we get by the official method 18.61 per cent available P_2O_5 ; by adding 1 cubic centimeter of 10 per cent ammonia to 100 cubic centimeters of the neutral citrate ammonia solution, and using this in place of the official solution, we obtained 25.32 available P_2O_5 . Certainly by concerted action the association might throw much light on this subject during the year. According to all preconceived ideas aluminum phosphate should be available to plants, and we should hesitate to continue a method of analysis, without thorough investigation, which gives less than one-half of the phosphoric acid as being available.

The question of the division of cattle foods should, I believe, receive the careful consideration of this association. Mr. Wiley called attention last year to the fact that it was impossible to analyze grains by the method as adopted. This is self-evident to all those who have such work to do. I would suggest, therefore, that the subject of cattle foods be divided into fodder analysis and grain analysis.

Ash analysis is an important subject and one that must necessarily receive the attention of experiment stations. If the experiment stations are to look to us for methods we should begin at once to systematize a method for ash analysis. This would probably require the appointment of another reporter.

The work of the individual members analyzing the uniform samples sent out by the various reporters has been the chief cause of our progress and success. Nothing should be done to discourage this important feature of our work, but as the association continues to take up new subjects for investigation the time will soon come, if not already at hand, when it will be too much of a task for each member to analyze all the samples. I believe the tendency is for the members to select too many subjects and not give enough attention to duplication or investigating new methods. Some plan by which it would be the duty of the members, grouped into divisions, to take up special work would, I believe, be feasible and successful.

In conclusion allow me to state, in the words of my predecessor, that the aim of this society is "to lay a foundation so solid that every court in this land must respect its conclusions, and every analytical chemist,

whether he lives in this country or elsewhere, must be forced either to practice or admit the advantages and correctness of our system of analyses. Step by step we have advanced through the difficult problems before us, feeling that we have steadily gained ground and that we are molding public sentiment in a manner that must redound to the advantage of the whole country and secure the highest respect for the science to which we are devoting our lives."

Mr. Wiley presented the following report of the executive committee on order of business:

PROGRAMME.

HOURS OF MEETING.—Morning hours, 9.30 to 12.30; afternoons, at 2.

1. Report on Determination of Nitrogen, by Mr. E. B. Voorhees.
2. Report on Analysis of Dairy Products, by Mr. E. H. Jenkins.
3. Report on Analysis of Potash, by Mr. N. T. Lupton.
4. Report on Analysis of Cattle Foods, by Mr. G. C. Caldwell.
5. Report of Committee on Foods and Feeding Stuffs.
6. Report on Analysis of Sugars, by Mr. H. W. Wiley.
7. Business meeting; election of officers, etc.
8. Report on Analysis of Phosphoric Acid, by W. B. Burney.
9. Report of Committee on National Chemical Society.
10. Report on Analysis of Fermented Liquors, by Mr. W. B. Rising.

The committee recommends that immediately following the reading of each report any written communications relating to the subject of such report shall be presented and read, the discussion upon the report to be deferred until such papers, if any, have been submitted to the association.

The committee announces that through the courtesy of the Assistant Secretary of Agriculture the services of Mr. Talma Drew, who made the stenographic report of the proceedings last year and aided the secretary in the preparation of the bulletin, have again been secured.

M. A. SCOVELL.
G. C. CALDWELL.
H. W. WILEY.
J. A. MYERS.

Mr. Myers moved that the report be accepted, and that the programme and recommendation therein contained be adopted. Carried.

Mr. Wiley stated that he had a letter from Mr. E. H. Jenkins, reporter on analysis of dairy products, inclosing his report, which would be read by the secretary when reached in the order of business. Mr. Jenkins was ill and could not attend the meeting. Mr. W. B. Rising, reporter on analysis of fermented liquors, had supposed that the meeting would be held in September, as it was last year. In connection with the preparation of his report he made a special trip to Europe, and had just sailed from Liverpool on his return. He had forwarded a partial report, and the work would be completed in time for publication in the bulletin.

Mr. Wiley announced that the committee on arrangements had made provision for an excursion on the following evening down the Potomac to Marshall Hall, where an excellent dinner would be served for the members and friends of the association.

The president suggested that it would be well to invite the Secretary and Assistant Secretary of Agriculture to attend the convention and address the members of the association.

Mr. Frear moved that a committee be appointed to extend the invitation of the association to Hon. J. M. Rusk, Secretary of Agriculture, and Hon. Edwin Willits, Assistant Secretary of Agriculture, to be present at the meeting. Carried; and the president appointed as such committee Messrs. Frear, Kedzie, and Caldwell.

Mr. Voorhees presented the following report:

REPORT ON DETERMINATION OF NITROGEN.

By E. B. VOORHEES.

As your reporter on nitrogen, I now have the honor to present the results of the work done by the association this year. As far as your reporter has been able to review the foreign and American journals he has not found that the past year has developed any particularly new or desirable additions to our present official methods. The report, therefore, will include chiefly (1) the results secured by members of the association, and (2) recommendations and suggestions.

Early in the year a circular letter asking coöperation in the work of the association was sent to all chemists connected with Experiment Stations, to seven commercial chemists, and to such others as were so entitled by our constitution, numbering in all about forty. Thirty-two, representing twenty-six stations, the United States Department of Agriculture, and that of Virginia, and five commercial chemists, signified their desire to take part in the work. Three samples were sent to each of these early in March, accompanied by another circular letter, asking that a moisture determination be made in each of the samples, and that the nitrogen determination be made according to the official and alternate methods. The report for 1889 had not then been distributed, hence they were asked to use those methods described in the report of the association for 1888, with such additional modifications as were recommended by the reporter in 1889. The samples were marked 1, 2, and 3, and were made up as follows:

Description of samples.		Percent nitrogen.	Grams.
No. 1:			
Potassium nitrate, containing.....		13.72	400
Sodium nitrate, containing.....		16.14	56
Calculated per cent of nitrogen.....		14.01	
No. 2:			
Linseed meal, containing.....		7.15	250
Cotton-seed meal, containing.....		5.50	250
Sodium nitrate, containing.....		16.14	100
Calculated per cent of nitrogen.....		7.96	
No. 3:			
Dried blood, containing.....		13.92	300
Ammonite, containing.....		13.02	300
Calculated per cent of nitrogen.....		13.47	

The report includes the work of twenty-four chemists, representing but fourteen of the twenty-five Experiment Stations which early in the season desired to coöperate, and the Departments of Agriculture of the United States and of Virginia. No commercial chemists are represented.

RESULTS.

The percentage of moisture was not reported by all of the chemists, and since the amounts reported in samples 1 and 3 were very uniform, all results are based upon original substance. The method of standardizing the acid was mentioned in only three reports; in these the tetra-oxalate was used with good results.

KJELDAHL MODIFIED FOR NITRATES.

Analysts.	Per cent nitrogen.	
	No. 1.	No. 2.
Walker Bowman (Virginia Experiment Station).....	13.95	7.49
R. C. Kedzie (Michigan Experiment Station).....	14.04	8.40
H. R. Baldwin (West Virginia Experiment Station).....	13.73	7.88
F. B. Carpenter (North Carolina Experiment Station).....	13.76	7.36
H. J. Patterson (Maryland Experiment Station).....	13.82	7.66
B. F. Finney (Virginia Experiment Station).....	13.86	7.77
R. H. Gaines (Virginia Department of Agriculture).....	14.13	7.68
T. C. Trescott (United States Department of Agriculture).....	13.40	7.65
J. M. Bartlett (Maine Experiment Station).....	14.12	7.64
L. H. Merrill (Maine Experiment Station).....	14.20	7.74
W. H. Beal (Massachusetts Experiment Station).....	13.80	7.61
F. W. Morse (New Hampshire Experiment Station).....	14.13	8.04
C. L. Parsons (New Hampshire Experiment Station).....	14.05	7.79
C. D. Woods (Storrs Experiment Station).....	14.04	7.97
Duncan Adriance (Texas Experiment Station).....	13.79	
A. L. Winton and R. S. Curtis (Connecticut Experiment Station).....	13.74	7.74
L. A. Voorhees and C. S. Cathcart (New Jersey Experiment Station).....	14.04	7.94
B. B. Ross (Louisiana Experiment Station).....	14.11	7.87
G. L. Holter (Pennsylvania Experiment Station).....	13.45	7.81
M. A. Scovell (Kentucky Experiment Station).....	14.08	7.99
A. M. Peter (Kentucky Experiment Station).....	14.02	8.03
H. E. Curtis (Kentucky Experiment Station).....	13.99	7.93
Average of whole number.....	13.91	7.80
Average of twenty.....	13.96	7.81

KJELDAHL METHOD.

Analysts.	Per cent nitrogen.
	No. 3.
Walker Bowman (Virginia Experiment Station).....	13.35
R. C. Kedzie (Michigan Agricultural College Experiment Station).....	13.72
H. R. Baldwin (West Virginia Experiment Station).....	13.45
F. B. Carpenter (North Carolina Experiment Station).....	13.40
H. J. Patterson (Maryland Experiment Station).....	13.55
B. F. Finney (Virginia Experiment Station).....	13.72
R. H. Gaines (Virginia Department of Agriculture).....	13.77
T. C. Trescott (United States Department of Agriculture).....	13.16
J. M. Bartlett (Maine Experiment Station).....	13.54
L. H. Merrill (Maine Experiment Station).....	13.63
W. H. Beal (Massachusetts Experiment Station).....	13.26
F. W. Morse (New Hampshire Experiment Station).....	13.31
C. L. Parsons (New Hampshire Experiment Station).....	13.46
C. D. Woods (Storrs Experiment Station).....	13.49
Duncan Adriance (Texas Experiment Station).....	13.07
A. L. Winton and R. S. Curtis (Connecticut Experiment Station).....	13.43
L. A. Voorhees and C. S. Cathcart (New Jersey Experiment Station).....	13.46
B. B. Ross (Louisiana Experiment Station).....	13.71
G. L. Holter (Pennsylvania Experiment Station).....	13.08
M. A. Scovell (Kentucky Experiment Station).....	13.63
A. M. Peter (Kentucky Experiment Station).....	13.53
H. E. Curtis (Kentucky Experiment Station).....	13.49
Average.....	13.46

RUFFLE METHOD.

Analysts.	Per cent nitrogen.		
	No. 1.	No. 2.	No. 3.
F. B. Carpenter (North Carolina Experiment Station).....	13.49	7.41	13.39
H. J. Patterson (Maryland Experiment Station).....	13.72	7.70	13.71
T. C. Trescott (United States Department of Agriculture).....	13.82	7.75	13.55
W. H. Beal (Massachusetts Experiment Station).....	13.84	7.62	13.28
G. L. Holter (Pennsylvania Experiment Station).....	13.30	7.80	
Average.....	13.63	7.66	13.48

SODA-LIME METHOD.

Analysts.	Per cent nitrogen.
	No. 3.
H. J. Patterson (Maryland Experiment Station).....	13.73
H. E. L. Horton (United States Department of Agriculture).....	13.46
W. H. Beal (Massachusetts Experiment Station).....	13.29
C. D. Woods (Storrs Experiment Station).....	13.56
New Jersey Experiment Station.....	13.44
G. L. Holter (Pennsylvania Experiment Station).....	13.30
Average.....	13.46

ABSOLUTE METHOD.

Analysts.	Per cent nitrogen.	
	No. 1.	No. 2.
T. C. Trescot (United States Department of Agriculture).....	13.77	7.79
A. L. Winton and R. S. Curtis (Connecticut Experiment Station).....		7.67

TABLE OF AVERAGES.

Method.	Number of sample.	Number of analysts.	Per cent nitrogen.			
			Average.	Highest.	Lowest.	Difference.
Kjeldahl.....	3	22	13.46	13.77	13.07	0.70
Kjeldahl modified for nitrates.....	1	22	13.91	14.20	13.40	0.80
	2	21	7.81	8.40	7.36	1.04
	1	5	13.63	13.84	13.30	0.54
Ruffle.....	2	5	7.66	7.80	7.41	0.39
	3	4	13.48	13.71	13.28	0.43
Soda-lime.....	3	6	13.46	13.73	13.29	0.44

All of the chemists represented reported results by the official methods; those reported by the alternate are in addition to the official.

KJELDAHL MODIFIED FOR NITRATES.

Remarks.—The average of the results reported on sample No. 1 is 13.91; excluding two that report much less nitrogen than the sample is shown to contain, the average is 13.96, or .05 of 1 per cent less than the calculated percentage.

On a basis of an average of 13.96 per cent, nine chemists are within one-tenth of 1 per cent, the limit usually allowed for experimental error; thirteen chemists, or 65 per cent of the whole number, are within .15 of 1 per cent, the limit often allowed between duplicates; 20 chemists, or the whole number included in the average, are within .3 of 1 per cent, the limit of error allowed by commercial chemists for what is termed "factory work."

The average of the results on sample No. 2 is 7.81; if we exclude one which is evidently much too high, and one too low, the average remains the same, and is .15 of 1 per cent less than the calculated percentage. Eight chemists are within .1 of 1 per cent of either the calculated per cent of 7.96, or the average per cent secured of 7.81. Taking .2 of 1 per cent as the limit of error, eleven chemists are within the same on the basis of the calculated per cent, while on the basis of the average secured sixteen are within the limit. Inasmuch as more than half the whole number of results reported on this sample are lower than the average of 7.81, the result above noted would seem to indicate either that the calculated per cent was too high, or that on a mixture of this character the results secured by the official method are too low. While sample No. 2 is an unusual mixture and somewhat difficult to manage, I am of the opinion that the trouble is not with the method.

If we simply compare the average of this year with that of last year, the results by the modified Kjeldahl show no apparent improvement, yet the fact that the average this year represents the work of twenty-four experiment station chemists, some of whom are reported to be inexperienced, as against fifteen chemists last year, which number included commercial chemists of high standing, it indicates a slight improvement in the work, and seems to me to fully verify the statement made by Mr. Scovell, in his report for 1889, viz, "that the modified Kjeldahl method is an accurate and reliable one for the determination of nitrogen in fertilizers containing nitrates."

KJELDAHL METHOD.

The average of the determination reported on sample No. 3 is practically identical with the calculated percentage. Ten chemists are within .1 of 1 per cent of the average, and the difference between the highest and the lowest is but .43 of 1 per cent, a result which is highly satisfactory.

ALTERNATE METHODS.

The results on Nos. 1 and 2, by both the "Ruffle" and absolute methods, are lower than by the official, though a fair comparison can not be made, owing to the very few reports by these methods. The soda-lime method gave results practically identical with those secured by Kjeldahl.

In accordance with the recommendations made by the reporter in 1889 the chemists of the Kentucky Station reported results secured on official samples Nos. 1 and 2 by substituting for two grams of zinc dust and two grams of salicylic acid, 2 grams of zinc sulphide and 1 gram of salicylic acid.

Results.

Analysts.	Per cent. nitrogen.		
	No. 1.	No. 2.	Potassium nitrate, C. P.
M. A. Scovell.....	14.08	7.99	.....
A. M. Peters.....	.....	7.82	13.79
H. E. Curtis.....	13.99	7.76	.....
Theoretical	14.01	7.96	13.83
Average association results.....	13.96	7.81	.....

The above results are the averages of several determinations agreeing closely with each other.

A practical test of this method was also made at the New Jersey Station, where thirty-three samples of commercial fertilizers containing nitrate nitrogen, ranging from .1 to 2.62 per cent, were duplicated by the official Kjeldahl for samples containing nitrates and by the suggested modification.

2 grams salicylic acid and 2 grams zinc dust.	1 gram salicylic acid and 2 grams zinc sulphide.	2 grams salicylic acid and 2 grams zinc dust.	1 gram salicylic acid and 2 grams zinc sulphide.	2 grams salicylic acid and 2 grams zinc dust.	1 gram salicylic acid and 2 grams zinc sulphide.
3.51	3.63	4.96	4.94	3.31	3.31
3.51	3.59	3.03	2.99	1.32	1.24
2.53	2.50	2.69	2.70	1.25	1.31
4.21	4.24	4.21	4.26	2.82	2.78
4.36	4.32	4.06	4.07	3.16	3.04
3.03	2.91	1.90	1.88	2.80	2.74
3.97	4.03	3.22	3.31	2.41	2.38
2.69	2.78	1.85	1.83	4.56	4.56
2.22	2.17	4.12	4.99	3.42	3.34
3.03	3.00	1.10	1.06	3.18	3.30
4.55	4.56	1.45	1.39	3.13	3.08
3.54	3.62	2.91	2.85	.....	.....

The results were highly satisfactory. The difference in duplicates ranged from nothing to .12 of 1 per cent, with an average difference on the whole number of .02 of 1 per cent.

ERRORS DUE TO REAGENTS.

A few chemists reported difficulty in securing uniform results on sample No. 1 when different weights were used and the proper deduction made for error due to reagents. This is an important point and should be carefully noted in the study of methods. Mr. Woods, of the Storrs Station, says that "Kjeldahl modified has in blank determinations always given some nitrogen. Should not be surprised at this if it were not that we always obtained about the correct percentage of nitrogen in nitrates (pure salts) without the use of the correction thus obtained, and the results have always been too low when the correction has been used." His report on this point is of considerable value and is appended in full.

MODIFIED KJELDAHL METHOD.

Mean of four "blanks" gave nitrogen corresponding to .4 cubic centimeters of ammonia solution, equal to .0012 gram nitrogen.

With potassium nitrate (theory), 13.84 per cent; mean by Tiemann-Schultze method, 13.75 per cent nitrogen.

Per cent nitrogen.		
Without correction.		With correction.
	13.75	
	13.78	
	13.76	
	13.68	
Av.	13.74	13.27

Nitrogen in samples.

[Percentages calculated on water content at receipt.]

NO. 1.

Per cent nitrogen.			
Siemann— Schultze method.	Modified Kjeldahl.		
	Without correction.	With correction.	
	14.03	14.05	
	14.08	14.01	
	14.16	14.06	
	14.19		
Av.	14.09	14.04	13.57

Modified Kjeldahl method.		
	Without correction.	With correction.
<i>P. ct. N.</i>	<i>P. ct. N.</i>	
	7.92	
	8.02	
	7.96	
	7.98	
	8.00	
Average.	7.97	7.85

The work of Mr. Woods verifies the experience of the New Jersey Station, where the error due to reagents had previously been shown to be equivalent to .0010 gram nitrogen, and which had produced widely varying results on pure nitrates when the proper deduction had been made for different weights taken, the results being invariably from .2 to .5 of 1 per cent low when less than half a gram of the material was taken. The following determinations on sample No. 1 were made to illustrate this point.

Weight taken.	Without correction.	With correction.
<i>Gram.</i>	<i>Per cent.</i>	<i>Per cent.</i>
.9	13.93	13.82
.8	14.05	13.92
.7	14.12	13.98
.5	14.06	13.86
.5	14.04	13.84
.5	14.11	13.91
.4	14.04	13.79
Average..	14.05	13.87

The average of the four determinations on one-half gram or less, without correction, is 14.05; with correction it is 13.85, or .20 of 1 per cent less; the average of the three without correction on more than one-half gram taken is 14.03; with correction 13.91, or .12 less.

It seemed reasonable to infer from this work that the results secured without the deduction for error were nearer to the truth and hence they have been used in the report rather than the others. Further blank determinations were made with proper precautions at our station and it was shown that our assumed error was too great, since the variations in the results ranged from an equivalent of .0002 gram nitrogen to .0010 gram; in all cases within the limit of experimental error.

RECOMMENDATIONS.

I would recommend that the present official methods be continued for the coming year, but modified to include the use of 2 grams of zinc sulphide and 1 gram salicylic acid, instead of the 2 grams zinc dust and 2 grams salicylic acid, where duplicate determinations of nitrogen are made in fertilizers containing nitrates. My reasons for this are as follows:

(1) The results reported by this method are quite as satisfactory as by the official method.

(2) The zinc sulphide can all be added at once, and is, therefore, much less troublesome than the zinc dust.

(3) The oxidation is more rapid, and, owing to the fact that less salts are present, the distillation is more quiet.

SUGGESTIONS.

I would suggest, not as an improvement of the official methods, but in order to facilitate work and save expense: (1) That the digestion and distillation be performed in the same flask; (2) that metallic mercury be used instead of the mercuric oxide.

I would also suggest that the importance of the work of the association demands that the chemists coöperating should give it their best attention. It is not work that should be left until there is nothing else to do. And I would further suggest that the work of the reporter is largely a work of love, and he should receive the results at least one week before the annual convention.

The secretary stated that no written communications relative to the determination of nitrogen had been handed in, and the president announced that discussion upon the report was in order.

Mr. Huston said that, while he did not in the least question the value of the report, he desired to state that out of five hundred samples in his office not one contained nitrogen equal in amount to the least quantity determined in the samples sent out; moreover the mixtures were quite different, only one of the five hundred samples referred to containing nitrates. He realized that much of the difficulty experienced was due to nitrates, but it seemed to him that none of the samples represented the run of the work which fell to the lot of chemists west of the Alleghany Mountains, and he thought it proper that this matter should be taken into consideration when the next set of samples was sent out. His principal work was still upon raw bone, which was troublesome.

Mr. Wiley said that the mixtures of sample No. 1 were potassium nitrate and sodium nitrate, and he believed that the calculated percentage of nitrogen present in the mixture had been stated by Mr. Voorhees as 14.01 per cent. He would ask whether Mr. Voorhees had examined the two constituents of this mixture and was absolutely certain that they contained the full theoretical amount of nitrogen.

Mr. Voorhees said that the samples were very finely ground and thoroughly mixed; in making his own determinations they were mixed again. The percentage of nitrogen found in the potassium and sodium nitrate used formed the basis for calculating the amount that should be present in a uniform mixture of the two salts in the proportions indicated. In about ten analyses made before the samples were sent out the results were practically uniform, and the average was quite near the calculated percentage. The results reported to him indicated that the sample was thoroughly mixed. He had no other basis upon which to make his calculation, and had not supposed it impossible to make a thorough mixture of such materials when thoroughly pulverized.

Mr. Ross inquired whether Mr. Voorhees had tried the use of sodium hypophosphite, suggested by Mr. Burney last year.

Mr. Voorhees said that he had not.

Mr. Ross said that in several determinations he had used sodium hypophosphite instead of zinc dust, but in some cases had been so unfortunate as to lose portions of the solution, and had worked out but

one or two determinations. Sample No. 1 had given 13.99 per cent, which seemed rather low as compared with his other results; it now appeared, however, to be nearer the theoretical result than 14.11 per cent, which he secured by the regular method. In his opinion digestion took place much more rapidly than when zinc dust was used, and after the potassium permanganate was added, and the solution had cooled, it showed less tendency to cake, dissolved much more readily, and consequently gave a solution which required less dilution than when zinc dust was employed.

The president said that exact figures should be handed to the secretary for publication; oral reports could not be accepted.

Mr. Ross said that he had secured 13.86 per cent on sample of potassium nitrate. He could only report single determinations on potassium nitrate and on sample No. 1. He did not desire to state them as official, but merely gave them for what they were worth.

Mr. Van Slyke called attention to a method that was merely mentioned in the report made by Mr. Scovell last year (p. 85), being the method of J. W. Gunning, described in the *Zeitschrift für Analytische Chemie*, vol. 28, pp. 188-191, in which the author used one part potassium sulphate and two parts strong sulphuric acid. He (Mr. Van Slyke) could not now present figures, but wished to say that during the year he had used the method referred to a good deal with wheat middlings, flour, and various organic substances for the special purpose of comparison with the regular official method, and had found that the results by Gunning's method agreed as closely as did the duplicates by the official method. Dr. Morse, of Johns Hopkins University, had used the Gunning method in his laboratory for the past year in determining nitrogen in a large variety of organic compounds, and with very satisfactory results. The advantage of this mixture was in its great simplicity; only the potassium sulphate and strong sulphuric acid were used, the oxidation took place quietly and with comparative rapidity, and a perfectly clear mixture was made; no potassium permanganate or other oxidizing mixture whatever had to be added. The solution was very clear, and in the speaker's experience had always distilled without bumping, some special precautions being taken in that regard. By this method the accumulation of reagents was avoided, which was always a desirable object. He hoped that the method might be tested on the samples sent out this year.

Mr. Myers inquired whether Mr. Van Slyke had tried the method on bone meal.

Mr. Van Slyke said that he had not.

The president said that he had tried it with the pure nitrates of different kinds in the samples, and invariably lost nitrogen by driving off ammonium sulphate. He had made some experiments. It worked well with the cattle foods, but in large quantities the contents of the flask got solid and hard, so that he supposed ammonium sulphate went off.

Mr. Van Slyke said that in that case he used more sulphuric acid.

The president said that if too much were used the oxidation would not take place; the other method seemed simpler.

Mr. Van Slyke said that the method in the form stated was not intended to apply to nitrates.

The president said that his own remarks referred simply to nitrogen in the organic form.

Mr. Cooke said that he had used the Gunning method on perhaps fifty samples of milk nitrogens, and finally abandoned it because of the length of time required to complete the digestion, which he thought would average nearly twice as long as that of the official method. The results obtained were very good.

Mr. Voorhees said that he would like to hear from those members of the association who had used zinc sulphide instead of the zinc dust.

The president said that he used it in his laboratory.

Mr. Voorhees said that the reporter had forgotten that the use of zinc sulphide had been recommended by the reporter of last year, and since the report of the last convention had not appeared when his samples were sent out, it had not been included in his recommendation to the chemists taking part. He would like to have an expression of the opinions of those who had used it.

Mr. Farrington said that his results had been good. In the dried blood samples more even results were obtained by grinding finely. He wished to know whether, in the determination of nitrogen by the Kjeldahl method, as modified by Scovell, the reagents were to be added in any particular order—whether the chemists added the substance to the acid or the acid to the substance.

Mr. Voorhees said that the method required the addition of the acid to the substance; that was the method as published, and he had always followed the direction. His custom was to add to the substance the metallic mercury, then the mixture of sulphuric and salicylic acids, then the zinc sulphide; then came the digestion.

The president said that he had followed that method in former years, but found the results less accurate than those obtained when the sulphuric acid was added to the substance. In regard to the zinc sulphide he thought the results very remarkable. The sulphide could be thrown in and the work started; the oxidation would proceed very rapidly and the duplicates would compare better than those with zinc. There was liability to loss when zinc was added; it would flash up. He made his own zinc sulphide, but blackjack might be used.

Mr. Voorhees inquired whether, in the digestion of pure nitrates (sample No. 1), difficulty had been experienced in getting a perfectly colorless product. He had found that even when a colorless liquid was obtained there was still a crystallization which remained dark for some time. He had not found that the dark color made any difference in the results, but wondered what it meant, whether there was lack of oxidation, or some combination formed there which crystallized in that color.

Was the oxidation really complete when one got a colorless liquid, or was it necessary to continue until a perfectly colorless product was obtained?

The president said that he had not observed it.

Mr. Voorhees said that with the zinc sulphide added he had no trouble whatever; he got a colorless product in a short time, and the results were equally good.

The president said that on a trial of that method he obtained his results in thirty-five minutes.

Mr. Woods asked whether any member of the association had experimented in the determination of nitrogen by the Kjeldahl method, plain or modified, in samples of soils, say 10, 20, or 50 grams. This was a matter in which he was interested, and he had not met with much success.

Mr. Huston said that he had used the Kjeldahl method with peats and with some of the so-called "bogus" soils of Indiana, but these were so high in nitrogen that he had taken only a little material to work with. In that line the method had been very successful with him, but perhaps his conditions were not the same as those of Mr. Woods. For a year he had used a special flask to save transferring, and found a great advantage in that.

Mr. Woods said that for 100 grams of soil he used a flask four or five times the size of the ordinary Kjeldahl flask, but in his laboratory different results were obtained according as 5, 10, 20, 50, or 100 grams were analyzed; the more he used the lower were his results.

The president asked Mr. Woods if he preserved the proportion of acid in analyzing the various amounts.

Mr. Woods said that he did, and that if there were errors from excess of acid the resulting percentages ought to be larger rather than smaller.

The president said that it would be well to remember such suggestions as were made by the members of the association in the course of discussion, and to give them a trial in making the analyses for the ensuing year. It was desired to get the best and shortest methods possible. The reporter's recommendations were now in order.

Mr. Wiley stated his desire that each reporter should send to him, as secretary, the full method upon his subject, as the same should be modified and adopted in this convention. It would be easy to do this by cutting the pages embracing the subjects in the bulletin of last year and erasing and inserting matter, as might be required by the modifications agreed upon. Each reporter was responsible for his own report in the forthcoming bulletin.

Mr. Voorhees said that he had made but one recommendation, as follows:

I would recommend that the present official methods be continued for the coming year, but modified to include the use of 2 grams of zinc sulphide and 1 gram salicylic acid, instead of the 2 grams zinc dust and 2 grams salicylic acid, where duplicate

determinations of nitrogen are made in fertilizers containing nitrates. My reasons for this are as follows :

(1) The results reported by this method are quite as satisfactory as by the official method.

(2) The zinc sulphide can all be added at once, and is therefore much less troublesome than the zinc dust.

(3) The oxidation is more rapid, and owing to the fact that less salts are present the distillation is more quiet.

Continuing, Mr. Voorhees said that he did not recommend this method as one to be used exclusively, but thought that in the case of fertilizers containing nitrates it worked better.

Mr. Cooke asked whether the change indicated was the substitution of the figure 1 for the figure 2 in the last line on page 220.

The president replied that the change recommended was as stated by Mr. Cooke, with the further substitution of zinc sulphide for zinc dust.

Mr. Cooke asked whether the word "*gradually*," in line 1 on page 221, was to be retained or omitted.

The president said that it might be left out ; the zinc sulphide could be thrown in if desired ; it made no disturbance.

Mr. LUPTON. I would suggest that we put in there what we have here, and say *or* zinc sulphide.

The PRESIDENT. The amendment suggested is that we use the old method or 1 gram of salicylic acid and 2 grams zinc sulphide, in which case the zinc sulphide can be put in at once.

Mr. Voorhees accepted the amendment, and his recommendation as modified thereby was adopted.

Mr. Voorhees stated that, in addition to the recommendation, which had been passed upon, he had made some suggestions, at the end of his report, as follows :

I would suggest, not as an improvement of the official methods, but in order to facilitate work and save expense : (1) That the digestion and distillation be performed in the same flask : (2) that metallic mercury be used instead of the mercuric oxide.

I would also suggest that the importance of the work of the association demands that the chemists coöperating should give it their best attention. It is not work that should be left until there is nothing else to do. And I would further suggest that the work of the reporter is largely a work of love, and he should receive the results at least one week before the annual convention.

The president said that the suggestions would be considered one at a time.

Mr. Voorhees said, in regard to the first suggestion, that he had found the rapidity of the work very materially increased by digesting and distilling in the same flask, and that a flask thus used would last quite as long as one used for either digestion or distillation alone. Being asked whether his flasks were made to order, he said that he had had them made specially but did not now ; he thought it paid to have them made to order according to one's own idea. He had ordered them made somewhat thicker than usual. The flask he used was of about 500

cubic centimeters, and made in form of the ordinary 500 cubic centimeter flask, except that the bottom was round instead of flat; when made to order he had them made of rather heavy Bohemian glass, with the necks a little longer and more pear-shaped than those of the ordinary 500 cubic centimeter flask. He used a rose burner in which the holes were drilled at an angle of about 65° . The digestion was much more rapid than in the ordinary long-necked Kjeldahl flask, and a great deal of time was thus saved. In the digestion of some samples containing nitrates there was a bumping or something which checked the flask, but this was no more serious in a flask used for distillation alone than in one used for both digestion and distillation. The ordinary flask could be used but four, five, or six times.

The President said that he understood Mr. Voorhees's suggestion to be only a suggestion, not to be put to vote.

Mr. Voorhees said that the suggestion was made to be thought about by the members of the association. It did not alter the method or detract from its value and accuracy to use one flask instead of two; the suggestion was merely as to the saving of time. It was in the same line with the use of metallic mercury, which was easier to handle and gave a better oxidation than mercuric oxide.

Mr. Kedzie said that the modified form of flask referred to had been used in his laboratory and was found convenient and satisfactory; he would recommend it to any one who had not tried it, and thought that those who used it once would continue to do so.

Mr. Huston said that he had used a special flask like that described by Mr. Voorhees, a round-bottom 500 cubic centimeter flask, with a neck large enough to carry a No. 7 rubber stopper. At first he had expected to experience difficulty by reason of the material splashing on the sides and being hard to remove, and one of his assistants tried to see whether he could heat the acid enough to bring down all the solid matter even if it was carried far up in the neck. He found he could heat it so high that the drops of acid condensing in the neck would be carried within an inch of the top of the flask without any appreciable loss of nitrogen in the flask. He had never experienced any loss of nitrogen, and the many tests made had given good results.

Mr. Farrington said that he had used the flasks spoken of, and thought it would be wise to adopt them, the only objection being that they broke very easily.

Mr. Van Slyke said that by using a small glass funnel in a wide-mouthed flask, with a watch crystal over the mouth of the funnel, there would be no loss, and the acid would condense at a lower temperature and wash down the side very satisfactorily.

The president said that the question was on the adoption of the methods as amended.

Mr. Myers stated that the method adopted last year required the use of .7 gram of mercuric oxide. He thought that if the use of metallic

mercury were made an alternate method it should be incorporated at that point by inserting the words *or its equivalent in metallic mercury*.

The president said that he found a little nitrogen in mercuric oxide, and therefore thought that metallic mercury was better.

Mr. McDonnell asked whether the mercuric oxide was to be weighed each time. The direction was "approximately .7 gram," and he had always used a little scoop which held approximately that quantity.

The president said that he used a little stopcock with a slight depression in one side, so that every time it was turned it gave just so much. This had been suggested by some German chemist.

Mr. Kedzie moved that the amendment suggested by Mr. Myers be adopted. Carried.

Mr. Patterson asked whether the method, as it now stood, required the use of 1 gram of salicylic acid with the zinc sulphide and 2 grams with the zinc dust.

The president said that it did; 2 grams had to be used with zinc.

Mr. Patterson said that as he understood the amendment the two methods were now made into one, so that the amendment as it stood would have to be changed.

The president said that Mr. Patterson was mistaken; the insertion of the word *or* as suggested by Mr. Myers and moved by Mr. Kedzie, had set the matter right.

Mr. Ross referred to the matter of bumping in distillation, and stated that the method directed the addition of granulated zinc or pumice stone. For the past few months he had simply added one-half a gram of zinc dust immediately before the addition of the sodium hydrate, had experienced no trouble by bumping, and had not broken a flask or checked the bottom of one in the last forty or fifty distillations. The same plan had been tried at the Alabama Station, where it had worked very satisfactorily.

The president said that he saw an objection to this in that nearly all sodium hydrate contained nitrates.

Mr. Ross asked whether such sodium hydrate should be used.

The president said that it would probably have to be used.

Mr. Horton said that in one of the German universities the described method of using zinc with the sodium hydrate was almost universal, and was found very satisfactory.

Mr. Farrington said that the same plan worked very well with him.

Mr. Ross said that he would like to see it inserted in the report of Mr. Voorhees along with the granulated zinc or pumice stone.

The president said that it might be recommended to be tested with the samples sent out; it would have to be put in the form of an amendment.

Mr. Voorhees said that he would accept the suggestion as a suggestion merely, not as a recommendation to modify the method, because many chemists did not use zinc at all; the method only directed the

use of granulated zinc "when found necessary to keep the contents of the flask from bumping." In his own laboratory the zinc was not found necessary. He thought the suggestion a very good one in cases where something had to be used to prevent bumping.

The president said that the suggestion would be inserted if there was no objection.

Mr. Lupton moved that the proposed methods for the determination of nitrogen, as amended, be adopted. Carried.

Mr. Frear presented the report of the committee appointed to wait upon the Secretary and Assistant Secretary of Agriculture; the committee had invited them to attend the meeting of the association.

The president stated that the report of Mr. E. H. Jenkins on dairy products was now in order:

Mr. Voorhees said that before proceeding to that report he would like to ask one or two questions in regard to the nitrogen work. Only three of the chemists who analyzed the official samples this year had reported results obtained by their special methods in preparing the acids, and he would be glad to have the experience of the members in regard to the tetra-oxalate, and to know what were the results as compared with the other methods of testing the acid; it seemed to him that this was one of the most important things to be considered in the determination of nitrogen.

Mr. Cooke said that he had been in the habit of resting his faith upon Iceland spar for standardizing the acid until he received the tetra-oxalate sent out by Mr. Caldwell, with which he had made quite a number of determinations. He had been very much pleased with the results obtained on a comparison of the two, their agreement in most cases being within .1 of 1 per cent on the total amount of acid present, that is, .001 of the total acid; in other words, 100 cubic centimeters of one would not take more than 100.1 cubic centimeters of the other, using phenol-phthalein as an indicator.

The president asked Mr. Cooke whether he tried the silver chloride.

Mr. Cooke said that he never succeeded with silver chloride except when he took the precaution, in his case rather difficult, of doing the work late at night, when there was no daylight whatever; in recent work he had not attempted it. The particular sample of tetra-oxalate prepared by Mr. Caldwell had given remarkably close results as compared with Iceland spar and with oxalic acid; the reaction was very sharp.

Mr. Caldwell said that it was necessary to use carefully prepared litmus.

Mr. Cooke said that in the work referred to he believed he had used di-methyl aniline orange for the indicator when testing the Iceland spar, as was his custom; he preferred that to any other indicator; it was not acted on at all by carbonic acid; he would recommend it to the members of the association, and was sure they would like it. With vegetable acids, however, it was good for nothing.

Mr. Frear said that he had bought the so-called pure tetra-oxalate and found it worthless; he had therefore made a little for himself prior to receiving that sent out by Mr. Caldwell, and got satisfactory material after a number of crystallizations. That which he had bought was very nearly pure acid oxalate.

Mr. Caldwell said that Baker & Adamson's had been found very good. He would say that cochineal would not answer as an indicator; he had used a carefully prepared litmus. He had never used the indicator suggested by Mr. Cooke, and asked whether that was the ordinary methyl orange.

Mr. Cooke said that it was not; it was an entirely different thing.

By request of the president Mr. Caldwell (vice-president) took the chair.

Mr. Scovell said that he had made quite a number of experiments in regard to standard acid, and had brought a sample, hoping that some other member would do the same and that it might be examined here. After many carefully made experiments he was inclined to believe that the tetra-oxalate gave better results than the silver chloride; with the samples received from Mr. Caldwell his results had been very good, and he had then made a pound or two for his own use, and with that he secured concordant results every time.

Mr. Parsons said that his experience was similar to that of Mr. Scovell; he used tetra-oxalate and invariably got results somewhat (not much) higher than were given by the silver chloride.

The chairman said that the method of standardizing acid was very important; if some definite motion were made the matter could be more readily discussed.

Mr. Voorhees said that the recommendations made by himself, as reporter on nitrogen, and which had been adopted, included the recommendation contained in last year's method in regard to the tetra-oxalate. The object last year, and his object now, was to get an idea as to the use of tetra-oxalate. The recommendation being already in, he would not like to make a motion to take it out. He did not know what motion to make.

Mr. Woods said that with him sodium carbonate invariably gave too low results. He now used sulphuric acid, and by precipitation with barium chloride and by using ammonium chloride of known purity he obtained results that were almost identical. While the results with sodium carbonate had been too low the other (tetra-oxalate) had been too high; the averages of the two had just about hit the mean of the other methods.

The chairman said that if no motion to change were made it would be understood that tetroxalate was to be taken as the standard.

Mr. Cooke inquired whether cochineal was the only official indicator.

The chairman said that he so understood; he thought there should be a modification.

Mr. Cooke said that he would be willing to move that di-methyl aniline orange be inserted as an alternate, but supposed that such a motion would hardly be in order, so few members of the association having used that indicator; he had used it two years, and liked it very well. It might be put in as a suggestion and tried during the year.

The chairman said that, in his opinion, something should be substituted for the cochineal, which was certainly misleading, being exactly the indicator that could not be used. Litmus or di-methyl aniline orange might be substituted.

Mr. Woods said that he had prepared litmus as carefully as he knew how, and had rejected it five years ago as not being at all applicable in the soda-lime or Kjeldahl methods.

Mr. Farrington asked whether the indicator in question was to be used in the analysis or simply for standardizing the acid.

The chairman said that, as he understood, it was to be used in standardizing the reagents. Although it was rather out of order to move a change in methods already passed upon, it was surely desirable to have methods which were right.

It was moved that the methods for the determination of nitrogen be reconsidered. Carried.

Mr. Cooke said that on page 218 of last year's proceedings, under the heading "Apparatus and Reagents" in the Kjeldahl method, the direction to standardize said nothing about the indicator to be used, but from the fact that cochineal was the only indicator mentioned on the following page it would naturally be supposed that cochineal was intended to be used in standardizing. He moved that the words *cochineal or di-methyl aniline orange to be used as an indicator* be added at the end of section 1, page 218, under the heading "Apparatus and Reagents." The motion was seconded.

Mr. Woods asked what would be the use of including cochineal if it could not be used with the tetra-oxalate.

Mr. Myers said that he had understood Mr. Woods to state that litmus could not be used. The association could hardly get along without an indicator, but at present it seemed to be standing between the devil and the deep sea.

Mr. Horton said that perhaps coralline could be used; that was an excellent indicator.

A member stated that he had tried coralline and found that it would not work; he thought it was affected by the organic acid.

Mr. Robinson said that in his experience with the use of di-methyl aniline orange during the past year he found it gave a much sharper reaction than any other reagent which he had used.

Mr. Cooke's motion was carried.

Mr. Huston said that he understood this to refer solely to the standardizing of the acid, and thought that something should be added which would indicate to the workers that they were not to use one in-

indicator in the standardizing and another in doing the work; there was a vast difference between indicators. He moved that section 1, page 218, under the heading "Apparatus and Reagents," be further extended by adding the words *the same indicator to be used in the work as is used in standardizing the acid.*

Mr. Cooke said that such addition seemed to him unnecessary. In the use of indicators in his own work he had found that phenol-phthalein, for instance, would give a certain standard when tetra-oxalate was compared, and that then by comparing the acid made up in that way with ammonia or with caustic soda he got the same results by the use of cochineal. If one had a correct standard the indicator ought to give correct results where it was applicable to the process. For example, di-methyl aniline orange gave correct results in comparing an inorganic acid with an inorganic alkali, but taking the same indicator and using it with an organic acid, the results would not be correct. He thought it would be proper to use one indicator for standardizing and another for using the standard acid where the original indicator was inapplicable.

Mr. Scovell said that he agreed exactly with Mr. Cooke in that regard.

The motion was seconded and carried.

Mr. Woods said that the nitrogen reporter might be instructed to suggest to the stations the trial of different indicators in testing acids, the results to be reported, so that next year the association should have more definite information in respect to indicators than it had now.

Mr. Wiley said that it would take about half an hour to read the report of Mr. Jenkins on dairy products. It was now so near the hour fixed for recess that perhaps the association had better suspend business until after lunch, the afternoon session being set for 2 o'clock.

At 12.15 p. m., on motion, a recess was taken.

AFTERNOON SESSION, THURSDAY.

The convention was called to order by the president at 2 p. m.

Mr. Myers said that the recommendations made by the president in his address were based upon careful consideration as to what would be best for the interests of the association, and it was proper that they should receive due attention. He therefore moved that a committee of three be appointed to consider and report upon the recommendations contained in the president's address. Carried.

The president said that he would appoint the committee soon.

Mr. Caldwell said that he would like to have the report on nitrogen taken up again, as he wished to make a motion, which he thought all would agree to, namely, that sodium carbonate be omitted from the substances by which the standardization might be made. Something had been said against it, nothing had been said in its favor, and it

seemed to him that it would be better to leave it out altogether, even if the matter should have to be taken up again and again. He moved that sodium carbonate, as one of the substances used for the standardization of the acid, be stricken out.

The president said that if no objections were made the subject would be considered as before the convention; if objection were interposed it would be necessary to move a reconsideration.

No objection being made, the motion was held to be in order.

Mr. Myers said that a great many chemists had adopted the sodium carbonate upon the recommendation of Fresenius, and it might be well to understand why it should now be stricken out.

Mr. Caldwell said that it had been spoken of in this convention as inaccurate; he had never tried it, but those who had said that it did not give correct results. He thought that the difficulty of getting the substance pure would be generally admitted. There was every reason to suppose that accurate results could be had with the silver nitrate. If the sodium carbonate were left in some might use it. His objection was based upon what others had said concerning their experience.

Mr. Cooke said that Mr. Caldwell's statement might be made still stronger. Probably there were more laboratories in the United States that used sodium carbonate as a method of standardizing than there were that used all the other methods put together, yet it was very hard to get correct results, and a large share of those obtained were slightly out of the way, though perhaps near enough for commercial work. In his own experience, and that of at least half a dozen chemists who had worked under him, it had been impossible to get an absolutely correct standardization with the purest sodium carbonate they had been able to obtain on the market.

Mr. Huston said that, according to his recollection, his assistant, Mr. Goss, made a precipitation on hydrochloric acid and also by carbonate of soda, and among all his results there was not a readable difference in the burette; he had said, if the speaker's recollection was correct, that of all the methods he preferred the sodium carbonate. Mr. Goss had spent a good deal of time on the work, did it carefully, and saw no objection to the use of sodium carbonate, and preferred it as more convenient. It might have been that theirs was an unusually good sample.

Mr. McDonnell inquired how Mr. Caldwell dried his potassium tetraoxalate.

Mr. Caldwell said that it was dried by simple exposure to the air.

The president said it was well known that sodium carbonate had been put in as one of the methods in order that the average of all might be obtained. In his experience last year it was found that sodium carbonate gave the lowest results of all, so that the average would not be as good with that method in as it would if it were out. He had tried the sodium carbonate anywhere obtainable and had made over a hundred experiments, but could not get concordant results. Personally he

thought it very objectionable, as a great many would use it or did use it, sometimes without testing it beforehand.

The motion was seconded and carried.

Mr. Wiley read a communication from Mr. E. H. Jenkins, reporter on dairy products, dated August 23, 1890, stating his inability, through illness, to attend the convention, inclosing his report, and requesting that the same be presented to the association by Mr. Wiley, as secretary.

Mr. Wiley read the report of Mr. Jenkins, as follows :

*ABSTRACT OF CHEMICAL LITERATURE RELATING TO THE ANALYSIS
OF DAIRY PRODUCTS.*

BUTTER.

Mac Farlane (Bull. No. 16, Lab'y of Inland Rev., Dept. of Can.) gives in detail one hundred and fifty analyses of Canadian butter collected from the markets. To thirty-three of the samples exception was taken on account of rancidity, or deficiency of butter fat. Water varied from 3.84 to 19.70 per cent, the average being 8.97; salt varied from 1 to 15.16 per cent, the average being 5.15. No margarin was found in any of the samples, the volatile fatty acids being equivalent, on the average, to 14.9 cubic centimeters $\frac{N}{10}$ potash solution.

Vieth (Milch Zeitg., 1890, 381) gives results of one hundred and ninety-eight butter analyses made during the last six years from samples having the following origin: Schleswig-Holstein, Denmark, Sweden, France (salted and unsalted), and England. The summary of these analyses is as follows:

Fat varied from 80 to 90 per cent. In three cases it fell below 80; in one it was over 90 per cent.

Water varied between the extremes 8.03 and 17.25; in most cases it was between 11 and 15 per cent. While a high per cent of water in butter is undesirable, too low a per cent is likewise detrimental, not only because it can only be caused by excessive working of the butter, but also because there is danger that the salt used in salting will either be imperfectly dissolved, or, once dissolved, will crystallize out if water evaporates slightly from the butter.

Salt, in Schleswig-Holstein butter, never rose above 2 per cent, and in several cases was less than 1 per cent. In Danish, Swedish, and French butters it was between 1 and 3 per cent.

In unsalted French butter there was generally found 0.1 per cent or less of chlorine. Where 0.2 or over were found the author judges that the butter has been washed in brine.

Especially valuable, as a basis of judging of the method of making the butter, is the relation between water and the sum of the other ingredients exclusive of fat and salt. In milk "serum," i. e. a fat-free milk to 100 parts of water, there are 10 parts of dry matter. About the same relation must exist in buttermilk free from fat, *provided* that radical changes have not taken place in the substance of the milk. When sweet or only slightly sour cream or milk is buttered the relation of water to solids not fat and salt will be about 100 to 10. But if the milk or cream were decidedly sour and in consequence casein had coagulated in larger and firmer lumps, the ratio of solids not fat or salt to water would be considerably greater than 10 to 100, while if the butter were washed the ratio would be considerably less than 10 to 100. The author regards a ratio of 9 or 10 to 100 as indicating nothing more than rinsing the butter with water but a lower ratio still as indicating washing.

St. Boudzynski and H. Rufi (Landwirthschaftl. Jahrb. d. Schweiz, 1889, Chem. Zeitg.

Repert. 1890, 20) propose two methods of determining volatile fatty acid in butter simpler than Wollny's.

(1) Four to 5 grams of butter are quickly saponified with 50 to 60 cubic centimeters of alcoholic $\frac{N}{2}$ potash solution, the excess of alkali is exactly neutralized with $\frac{N}{2}$ hydrochloric acid, the alcohol is expelled by evaporation, the soap is decomposed by hydrochloric acid and the separated insoluble fatty acids are filtered and washed with hot water, dissolved in alcohol and titrated with $\frac{N}{2}$ or $\frac{N}{4}$ potash solution. The difference between the quantity of potassium hydrate combined with all the acids and that required to neutralize the non-volatile (insoluble) acids represents the alkali necessary to neutralize the volatile acids.

(2) The butter fat is saponified as before, the alcohol expelled by evaporation and the aqueous soap solution in an Erlenmeyer flask is decomposed with a quantity of $\frac{N}{2}$ sulphuric acid exactly equivalent to the alkali used for saponification.

The flask is fitted with an inverted condenser, and the contents, made up to 400 or 500 cubic centimeters, are heated till the aqueous solution under the melted fat has become perfectly clear. Then the separated insoluble acids are washed out, and in the filtrate the volatile (soluble) acids are titrated with $\frac{N}{2}$ alkali solution.

Both methods give results which agree with each other and with the results of distillation. The quantity of volatile fatty acids and of their glycerides may be expressed in per cent of the butter fat. To this end the insoluble acids are rinsed into a tared flask with ether, and after evaporation the residue is dried and weighed, and then titrated. The alkali required corresponds to its equivalent of glycerol from which the glycerides of the insoluble acids are reckoned. This subtracted from the total quantity of the fat gives the quantity of glycerides of volatile acids.

The authors also state that free volatile acids can only be detected in butter which is in an advanced state of decomposition. Fresh butter contains free insoluble acids in small quantity, and rancidity is to be ascribed to the increase of these free, *insoluble* acids.

E. H. Amagat and F. Jean (Compt. rend. 1889, 109, 616, Abstr. Chem. Zeitg. Repert., 1889, 308) describe the use of their oleorefractometer, by which the presence of oleomargarine in butter is easily detected. The butter is melted at a low temperature, filtered through muslin, and dissolved in ether. This solution is washed with warm water, filtered, and after evaporation of the ether, is dried at 110°. The fat of genuine butter, so prepared, gives a constant deviation of 35° to the *left* compared with the fat of ox hoof oil as the standard. Margarin prepared from kidney fat of neat stock shows 19°, and margarin prepared by the Niede-Mouries process, 15°. Butter with 50 per cent of this margarin shows 23°; with 25 per cent, 28°, and with 10 per cent, 32°. An addition of less than 10 per cent is readily detected. The vegetable oils give a deviation to the *right*.

C. Viollette (Compt. rend. 1890, 111, 348) indorses the oleorefractometer as a useful instrument in distinguishing between pure butter and margarin. Pure butter varies between — 33° and — 27° in the deviation produced, margarin between — 15° and — 8°.

G. Ambühl (Chem. Zeitg. 12, 392, Abstr. Zschr. analyt. Chem. 1889, 18, 369) uses an apparatus to determine the apparent specific gravity of butter fat at 100° C., which is essentially like Soxhlet's apparatus for determining the specific gravity of the etherial fat solution obtained from milk. Soxhlet's water jacket is simply used as a steam jacket to keep the temperature at 100°.

Ed. von Raumer (Arch. f. Hyg. 1888, 8, 407 Abst. in Chem. Zeitg. Repert., 1889, 41) considers the Meissel-Reichert method of determining the volatile fatty acids of butter to be the most reliable. He prefers to saponify the fats in an open dish, con-

stantly stirring with a pestle to expel alcohol as quickly as possible and to avoid long heating, which even at 95° C. decomposes fatty acids. He claims, in opposition to Wollny, that the presence of carbonic acid exerts little influence on the result. The endeavor to obtain the total quantity of volatile fatty acids by repeated distillation he claims is useless, for there is constant decomposition going on, with formation of volatile acid.

P. van Hamel-Roos (*Rev. internat. des falsifications* 1890, 3, 116; *Abstr. Chem. Zeitg. Repert.*, 1890, 87) in three samples of butter found 0.8, 11.2 and 12.4 cubic centimeters $\frac{N}{10}$ alkali (by Reichert's method, 2.5 grams) respectively. He was informed that the first was margarin, the second butter with 25 per cent cocoa butter, and the third genuine butter. Cocoa butter alone required 4.5 cubic centimeters $\frac{N}{10}$ alkali.

P. Cosbetta (*Chem. Zeitg.* 1890, 406) from careful experiment concludes—

(1) The content of volatile fatty acids in butter (determined by Wollny's modification of Reichert-Meissel) suffers a decided progressive loss in becoming rancid.

(2) This loss is not very considerable; the maximum in his experiments was 2 cubic centimeters $\frac{N}{10}$ alkali.

(3) No volatile fatty acid is withheld from rancid butter by washing with water or sodium bicarbonate.

L. F. Nelson (*Zeitschr. analyt. Chem.* 1889, 28, 175; *Abstr. in Chem. Zeitg. Repert.* 1889, 121) finds that the volatile acids from the conventional quantity of colostrum fat require only 18.5 to 20 cubic centimeters of alkali for neutralization, instead of 25 cubic centimeters or more. In the course of five to seven days after calving the maximum content of fatty acids is reached, and after a few days slowly and regularly decreases till it equals only 24 cubic centimeters of alkali at the end of lactation. Season of the year and feeding have no effect on the quantity of volatile fatty acid.

P. Vieth (*Analyst* 15, 45) presents in some detail the results of 20,674 analyses of milk, 1,123 analyses of cream, and 104 samples of butter; the latter of English, French, Danish, Swedish, and German origin. In certain samples of butter from Kiel the volatile fatty acids determined by Wollny's method were equivalent to only 21.1 cubic centimeters $\frac{N}{10}$ alkali, but that they were pure butter was not demonstrated.

MILK.

Hittcher (*Mitth. a. d. Versuchs-Molkerei Kleinhof-Tapian*, abstr. in *Vierteljahr-esschr. d. Chem. d. Nahrungs- u. Genussmittel*, 1890, 5, 2) has made a special study of the quality of milk of individual cows. Among the most important observations are these:

(1) Certain cows in the whole period of lactation produced twice as much milk fat as others.

(2) During heat, the per cent of fat in the milk of certain cows sank extraordinarily: as low as 0.7 per cent, while others were scarcely affected at all.

(3) Poor quality of milk is a trait which is transmitted from a cow to her offspring.

(4) Quality of milk is an individual peculiarity and high quality of milk is perhaps sooner and cheaper obtained by selection of cows than by rich feeding.

M. Kühn (*Milch-Zeitg.*, 1889, 47, 923) has made analyses of milk from eleven individual cows new in milk and from eleven others towards the end of lactation, both sets being of approximately the same age, of the same strain, and having the same food and care. He finds that on the average the cows new in milk gave considerably more milk than the others, but less rich in solids, fat, and albuminoids; sugar and ash were about the same. In a single case the specific gravity of the milk of a single cow was 1.0272 and in three cases among the cows old in milk and three in new milk cows the specific gravity was below 1.029, which is regarded as the lowest limit for pure milk.

The milk of old milkers showed the greater variations in dry substance, sugar, and especially in fat.

By the use of Fleischmann's formulas, according to the tables in *Milchwirthschafft. Taschenbuch* 1889, for calculating solids or fat, in all cases the dry matter runs from 0.1 to 0.6 per cent higher than was found by analysis, and the fat correspondingly lower. The author suggests that the formulas may not hold perfectly for all races of calves or for all kinds of feed.

F. J. Lloyd (*Jour. Chem. Soc.*, 1890, 57, 201) gives analyses of abnormal milk from two cows in a herd. The cows were to all appearance healthy. Their food was ample, and other cows of the same herd and under the same conditions were giving rich normal milk. They were cross bred Shorthorns and one of the two appeared to have some Dutch blood. The quantity of milk was "not large, and is decreasing rapidly." It was about 38 pounds per day in November, and fell in one case to 8 and in the other to 18 pounds in January. Some of the samples were drawn by the author himself after seeing the cows milked. Others were sent by the owner after supervising the milking.

In the morning milk, which was the poorest, the total solids ranged from 10.04 to 11.88; the fat from 2.17 to 3.44; solids not fat from 7.50 to 8.47.

Isbert and Venator (*Ztschr. f. angew. Chem.*, 1890, 85; abstr.; *Chem. Zeitg. Repert.*, 1890, 41) find the mixed milk of fifty cows from one stable to have the following composition:

Specific gravity at 15°	1.0355
Fat	per cent.. 2.6
Solids	do... 10.9
Creamometer	do... 7.0

Perron (*Jour. Phar. Chim.*, 1890, 5 ser. 21, 63; abstr. *Chem. Zeitg. Repert.*, 1890, 42) notes an adulteration of milk with olive oil emulsified with borax or yolk of egg. The fat separates from such adulterations rather incompletely. Borax is readily detected by the spectroscope in the milk ash, and oil by determining the freezing point of the fatty acids, which in acids from pure butter fat lies between 37.5° and 38.5°, while the acids from oils melt at a temperature lower by some 10°.

H. D. Richmond (*Analyst*, 1889, 14, 2), after trying the preservative action of alcohol, carbon disulphide, ether, dichlorophenol, chloroform, and terpenes, which were unsatisfactory, found that milk could be most satisfactorily preserved by the addition of 0.5 per cent of commercial hydrofluoric acid. This is equivalent to one drop in 10 cubic centimeters. The casein was precipitated, but by gentle shaking is brought into such a fine state that sampling is easy and the fat is evenly and thoroughly distributed. The milk must be *fresh* when treated. The author gives results showing that the determinations of solids and fat made in the fresh samples and in the same samples after being kept for periods varying from a month to nearly a year, were nearly identical.

Schweissinger (*Phar. Ctrlb.*, 1890, 6; abstr. in *Vierteljahresschr. Nahrungs-u. Genussmittel*, 1890, 5, 16) describes an areopycnometer designed to determine the specific gravity of milk when only a small quantity of milk is available. (See *Milch Zeitg.*, 1890, 4.)

H. D. Richmond (*Analyst* 1890, 16, 170) emphasizes the fact that the specific gravity of milk must not be determined until twenty-two hours after milking, as in the mean time it becomes denser, and after shaking the milk in preparation for the specific gravity determination special care must be taken to remove bubbles which are held by milk tenaciously. Referring to his formula for calculating fat from the solids and density, $T = 1.17 F + \frac{263 G}{D}$ he now extends the formula to include the calculation of milk sugar and proteids; the density, fat, total solids, and ash being known. P = proteids; T = total solids; A = ash; F = fat; D = density; water at 60° Fah. being taken as 1; and $G = 1000 D - 1000$.

The formula is $P = 2.8 T + 2.5 A - 3.33 F - \frac{7G}{D}$

The difference between total solids and the sum of fat, proteids, and ash gives milk sugar. The assumption that the solids contain no other substance involves a small error. A second and larger error is due to the fact that the ash of milk does not represent the salts of milk because of the destruction of organic salts by ignition. By use of the formula the author calculates the influence of 1 gram of each constituent in 100 cubic centimeters on the density, and from that the density in solution, and compares this calculated density with direct determinations of the density of the constituents made by different observers, as follows:

	Influence of 1 gram in 100 cubic centimeters	Calculated density.	Observed density.	Observer.
Fat	0.76	0.929	0.93	(Fleischmann, Jour. f. Landw., xxxiii, 251.)
Sugar	4.00	1.667	1.65	(Many observers.)
Proteids ..	2.57	1.346	1.34	(Dupré, Analyst, viii, 248.)
Ash	7.57	4.12	3.00	(Dupré, <i>loc. cit.</i>)

The cause of disagreement in ash has been pointed out.

G. Mariani (Italian Experiment Stations, xxii, 1889; Abstr. in Chem. Zeitg., 1890, 64), for the absorption of milk in the determination of solids and fat, indorses the use of paper pulp extracted thoroughly with petroleum ether, which has been recommended by Gaunter. He found that the method of drying the milk by itself without any absorbent, and drying it with wood paper pulp gave nearly identical results. In twelve determinations made by each method the greatest difference between the total solids found by the two methods was less than 0.1 per cent. Drying with sand gave somewhat higher results. The drying with pulp was quicker done than with sand. When 10 to 12 grams of milk were used with 5 grams of pulp, the drying was finished in three hours. The author considers the sand method preferable where great accuracy is required.

The fat determinations, made by extracting the dried sand or pulp residues in a Soxhlet's extractor, with absolute ether, showed satisfactory agreement. The greatest difference, among twelve determinations, was 0.215 per cent, and the average difference 0.09 per cent. He found five hours sufficient for the complete extraction of fat from sand, while the extraction of paper pulp was complete in three hours.

P. Vieth (Analyst, 15, 45) finds a close relation between the per cent of non-fatty solids, and ash in milk and cream. The ash is equal to just 8 per cent of the non-fatty solids. He regards this as a useful check in analysis and a test of the normal quality of a milk.

P. Radulescu (Mittheil. a. d. phar. Inst. u. Labor. f. angew. Chem. d. Universität Erlangen, v. A. Hilger, 1890, 3, *93; Abstr. Chem. Zeitg. Repert., 1890, 174) has examined the statements regarding the determination of the specific gravity of milk serum as a means of judging of its genuineness.

To coagulate milk, 100 cubic centimeters of milk are heated with 2 cubic centimeters of 20 per cent acetic acid on a waterbath, so that the milk itself is kept at a temperature of 55° to 65° for five minutes. It is not stirred during the time. The clear serum is then filtered off and its specific gravity determined by the pycnometer or the Westphal balance.

The author concludes—

- (1) The specific gravity of a serum or whey of normal milk is never less than 1.027.
- (2) Addition of 10 per cent of water to normal milk lowers the specific gravity of the serum by 0.0005 to 0.001.
- (3) The dry matter and fat of serum should always be determined.
- (4) The serum always has 6.30 to 7.5 per cent of solids and 0.22 to 0.28 per cent of fat.

(5) Addition of 10 per cent of water to normal milk causes a diminution of solids in the serum of 0.3 to 0.5 per cent.

Charles Rice (Jour. Analyt. Chem., 1890, 4, 155) proposes to substitute for Adams's paper coils for fat determinations in milk "absorbent gauze," also called "bleached hospital gauze," a light open-mesh cotton fabric, having about forty threads to the linear inch, and weighing about $1\frac{1}{4}$ ounces per square yard.

"The milk coils, or cartridges, consist of a small roll of this gauze, inclosed in a wrapper of blotting paper, and their mode of preparation is as follows:

"Spread out a square yard of the gauze on a flat surface; fold it twice in one direction to reduce it to 36 by 9 inches; then fold it upon the long side in laps of $1\frac{1}{4}$ inches in width, so that when the whole is folded it will present a strip of 1 yard in length, and about $1\frac{3}{4}$ to $1\frac{7}{8}$ inches in width, and will consist of some eighteen to twenty layers.

"Now begin to roll the strip up on the narrow end, like a bandage, but not too tight, until about 5 or $5\frac{1}{2}$ inches of the gauze have been rolled up; cut the strip slantingly, that is, not perpendicular to its body, but under an angle, so as not to cause "bunching" when wrapped in paper. Place the roll upon a strip of blotting paper 4 inches long and $2\frac{3}{4}$ inches wide, and roll the latter over it so as to have it (the paper) project at one end about one-fourth inch over the gauze coil, and about three-fourths inch at the other; then tie the coil with two threads. It will thus be $2\frac{3}{4}$ inches long and about seven-eighths inch in diameter." Here is given a figure of the coil with explanations.

"The larger compartment of this cartridge serves as a funnel, into which the full quantity of the milk to be tested is poured at once. A coil of this kind, intended for the smallest size of Soxhlet's extractor, will easily take from 8 to 10 grams of milk, and the latter will never entirely soak down to the bottom of the paper wrapper. If it should soak to the bottom of the gauze coil, this will do no harm, as it is one-fourth inch above the end of the paper."

Babcock (Wis. Exp. Sta. Bull., No. 24) describes a new method for determining fat in milk, especially adapted to creameries and cheese factories, as follows:

DESCRIPTION OF APPARATUS AND CHEMICALS REQUIRED.

(1) *Test bottles* (Fig. 1).—These are of the same form as the bottles used in Short's test, but are made a little smaller and of heavier glass. They should contain up to the neck not less than 40 cubic centimeters nor more than 45 cubic centimeters. Each division of the graduated scale upon the neck represents 0.04 cubic centimeters, and in order to facilitate the reading the neck is made of such a diameter that the marks of the scale are about $1\frac{1}{2}$ millimeters apart. Five of these divisions are equivalent to 1 per cent of fat when 18 grams of milk are used in the test, it being assumed that the specific gravity of the butter fat, at the temperature at which the reading is made (about 120° F.), is 0.9.

(2) *Pipette for measuring milk*.—This may be of any form, but that shown in Fig. 2, with a rather wide opening at the lower end to allow the milk to run out rapidly, is to be preferred. It should contain, when filled to the mark, 17.6 cubic centimeters. A pipette of this size will deliver a little less than 17.5 cubic centimeters of milk. The quantity of milk required for the test sample of 18 grams is 17.44 cubic centimeters, if the milk has the average specific gravity of 1.032.

(3) *A measure for the acid*.—A graduate or cylinder of glass (Fig. 3), with a lip to pour from and a single mark at 17.5 cubic centimeters, is the best form for general use. In laboratories a large burette, holding 100 or 200 cubic centimeters with marks at each 17.5 cubic centimeters and having a glass stopcock, may be used to advantage, but on account of the liability of breakage is not to be recommended in factories or private dairies.

(4) *A centrifugal machine*.—Figs. 4 and 5 show the construction of the machine used by us. The gear in this apparatus is so proportioned that the wheel which

carries the test bottles makes about ten revolutions to one of the crank ; with this it is easy to impart from seven to eight hundred revolutions per minute to the horizontal wheel. Any arrangement that will do this, either by belt or gear, will answer the purpose. Within the horizontal wheel (*a*, Fig. 5) are placed sectors (*b*) made from heavy sheet copper to which are soldered cups or tubes (*c*), inclined so as to make an angle of about 30° with the horizontal, for the support of the test bottles. The horizontal wheel is surrounded by a copper jacket (*d*, Fig. 5) with a cover. This serves the double purpose of supplying heat for the test by pouring hot water into it, or by heating water directly with a lamp placed beneath, and of arresting the hot acid which would fly off if a bottle should break.

(5) *A kerosene or gas lamp* for heating two or three quarts of water to boiling.

(6) *Commercial sulphuric acid*, having a specific gravity of 1.82 or about 90 per cent pure. If only the pure acid is available, it should be diluted with water to the strength indicated.

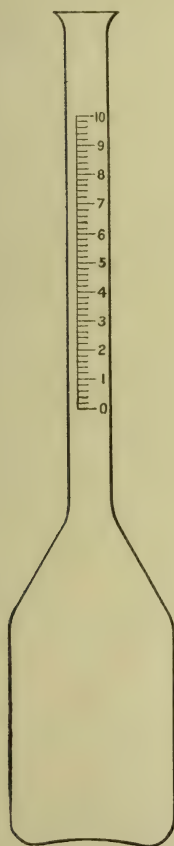


Fig. 1.



Fig. 2.

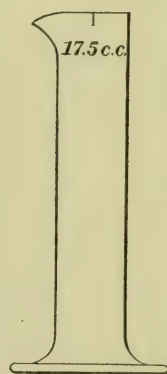
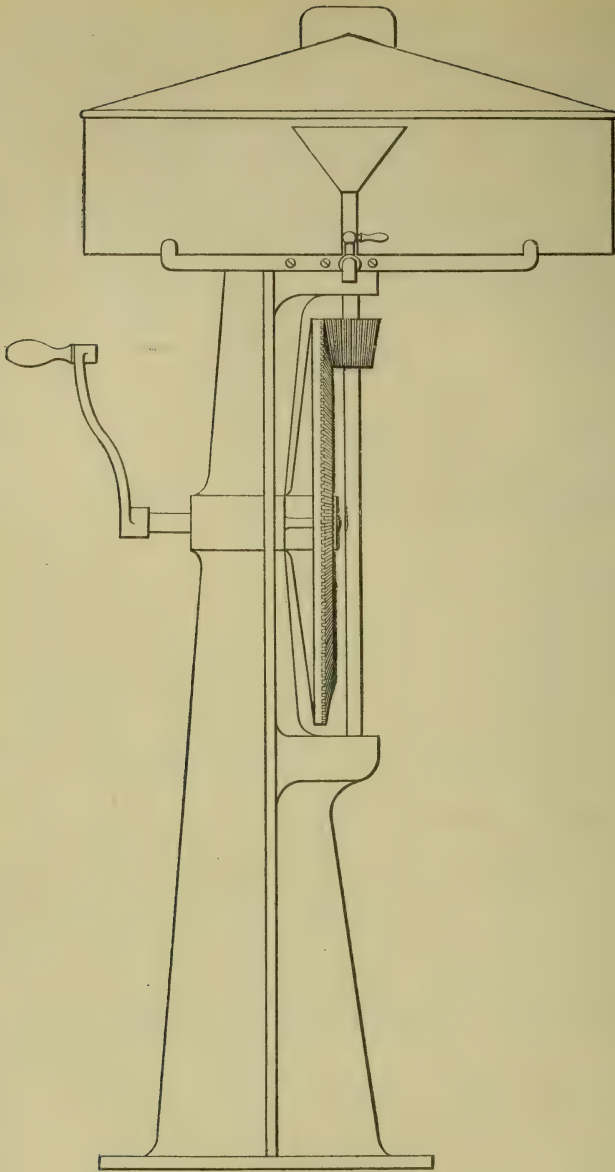


Fig. 3.

*Fig. 4.*

THE TEST.

Sampling the milk.—Every precaution should be taken to have the sample represent as nearly as possible the whole lot of milk from which it is taken. Milk fresh from the cow, while still warm and before the cream has separated in a layer, may be thoroughly mixed by pouring three or four times from one vessel to another. Samples taken at once from milk mixed in this way are the most satisfactory of any. Milk that has stood until a layer of cream has formed should be poured more times until the cream is thoroughly broken up and the whole appears homogeneous. No clots of

cream should appear upon the surface when the milk is left quiet for a moment. With proper care any milk that has not coagulated, or that has not been exposed to the air until the surface of the cream has become dried, may be mixed so that a representative sample may be taken. Milk should not be poured more times than is necessary, as continual mixing in this way is liable to churn the cream, forming little granules of butter that quickly rise to the surface. When this occurs it is impossible to obtain a fair sample. Milk is sometimes churned by being transported long distances in vessels that are not full. When this occurs it is useless to make an examination.

It is impracticable to sample a large amount of sour milk, but a small sample of a pint to a quart may be thoroughly mixed by adding five per cent of strong ammonia water which will dissolve the curd and permit a uniform mixture being made. When ammonia is added, the final results should be increased by 5 per cent. Samples from sour milk are, however, never as satisfactory as those taken when the milk is in a proper condition.

Measuring the milk.—When the milk has been sufficiently mixed, the milk pipette is filled by placing its lower end in the milk and sucking at the upper end until the milk rises above the mark on the stem; then remove the pipette from the mouth and quickly close the tube at the upper end by firmly pressing the end of the index finger upon it to prevent access of air; so long as this is done the milk can not flow from the pipette. Holding the pipette in a perpendicular position, with the mark on a level with the eye, carefully relieve the pressure on the finger so as to admit air slowly to the space above the milk. When the upper surface of the milk coincides with the mark upon the stem, the pressure should be renewed to stop the flow of milk. Next, place the point of the pipette in the mouth of one of the test bottles, held in a slightly inclined position so that the milk will flow down the side of the tube leaving a space for the air to escape without clogging the neck, and remove the finger allowing the milk to flow into the bottle. After waiting a short time for the pipette to drain, blow into the upper end to expel the milk held by capillary attraction in the point. If the pipette is not dry when used it should be filled with the milk to be tested, and this thrown away before taking the test sample. If several samples of the same milk are taken for comparison, the milk should be poured once from one vessel to another after each sample is measured. Neglect of this precaution may make a perceptible difference in the results, through the separation of cream, especially when the milk examined is rich.

Persons who have had no experience in the use of a pipette will do well to practice a short time by measuring water into a test bottle before attempting to make an analysis. The manipulation is easily acquired, and with a little practice milk may be measured nearly as rapidly with a pipette as with a graduate, and with much greater accuracy.

Adding the acid.—When the milk has been measured into the test bottles the necessary amount of sulphuric acid may be added immediately, or the bottles may be left for a day or two without materially changing the results; samples that have remained in the test bottles more than a week have given the same amount of fat as samples tested immediately after being measured. If the milk has become coagulated the curd should be broken up by shaking the test bottle before the acid is added.

The volume of commercial sulphuric acid required for a test is approximately the same as that of the milk, 17.5 cubic centimeters for the ordinary test. If too little acid is added, the casein is not all held in solution throughout the test, and an imperfect separation of the fat results. If too much acid is used the fat itself is attacked. The acid need not be measured with great accuracy; any quantity between 17 and 18 cubic centimeters will answer the purpose.

Great care must be taken in handling the acid to avoid getting any of it upon the skin or clothing, as it is very corrosive. If by accident any is spilled upon the hands or clothes, it should be washed off immediately, using plenty of water. A prompt

application of ammonia water to clothing upon which acid is spilled may prevent the destruction of the fabric and restore the color.

When all of the samples of milk to be tested are measured ready for the test, the acid measure is filled to the 17.5 cubic centimeter mark with sulphuric acid, and from this it is carefully poured into a test bottle, containing milk, that is held in a slightly inclined position for reasons given in directions for measuring the milk. The acid being much heavier than milk sinks directly to the bottom of the test bottle without mixing with the milk that floats upon it. The acid and milk should be thoroughly mixed together by gently shaking with a rotary motion. At first there is a precipitation of curd from the milk, but this rapidly dissolves. There is a large amount of heat evolved by the chemical action, and the solution, at first nearly colorless, soon changes to a very dark brown, owing to the charring of the milk sugar and perhaps some other constituents of the milk.

Upon standing a short time the fat begins to collect upon the surface, not in a clear layer, but having at first the appearance of a dirty cream. The separation of fat by gravity alone is not complete, even when the bottles are left standing for several hours; with the centrifuge, however, a perfect separation is accomplished in a few minutes.

Whirling the bottles.—The test bottles containing the mixture of milk and acid may be placed in the machine directly after the acid is added, or they may stand several hours without harm. An even number of bottles should be whirled at the same time, and they should be placed in the wheel in pairs opposite to each other, so that the equilibrium of the apparatus will not be disturbed. When all of the test bottles are placed in the apparatus, the cover is placed upon the copper jacket, and the machine is turned either by hand or by power at such a rate that the wheels carrying the bottles will make from six to eight hundred revolutions per minute, and this motion must be kept up for six or seven minutes. If this wheel is less than about 20 inches in diameter the speed should be greater, or else the whirling should be continued for a longer time.

When the bottles are placed in the machine directly after the acid is added, the separation may be effected without any extra heat, as that caused by the chemical action is sufficient to keep the fat liquid. If the bottles have stood after the acid is added until the contents are cooled below 100° F., the water in the tank should be warmed to about 200° F. before putting the bottles in the machine. The bottles should not be kept heated in the machine as high as the boiling point of water while the separation is being effected. The proper degree of heat may be obtained by lighting the burner or kerosene stove under the jacket when the machine is started, so much water having been poured into the jacket as will be just heated to boiling when the whirling is finished. In this way hot water is always available for filling the tubes at the proper time. In creameries heat can be most easily supplied by steam connection with the boiler. If the machine is stopped after about six minutes a layer of fat will be found upon the upper surface of the liquid in the tubes. This fat will not usually be clear; this, however, will make no difference in the result, as the subsequent treatment will clarify it.

As soon as the bottles have been sufficiently whirled they should be filled to the neck with hot water. This is most conveniently done by placing a vessel containing boiling water above the machine, and by means of a siphon, made from a small rubber tube with a glass tip, running the water directly into the bottles without removing them from the wheel. The flow of water can be perfectly controlled by a pinch-cock upon the rubber tube. If only a few tests are to be made the bottles may be easily filled with a pipette, or by pouring from a graduate. The cover should then be replaced and the machine turned for one or two minutes, after which more hot water is added, filling the tube to about the 7 per cent mark. The fat will slowly rise into the graduated tube, losing its cloudy appearance as it passes through the hot water. When all of the bottles are filled the cover is put upon the tank and the machine

again turned for a short time. During this time the water in the tank should be kept hot, either by placing a lamp or kerosene stove beneath it, or by pouring in a quantity of boiling hot water before starting the machine. If the fat in some of the tubes still has a cloudy appearance, the cover should be placed upon the tank and heat applied for a few minutes, when the fat should become clear and in condition to be measured. The clearing may be hastened by whirling the tubes while hot. When the bottles are allowed to cool off to a point where the fat will crystallize and then warmed again, the fat will usually be much clearer than before, but as this does not materially change the volume of fat it is considered unnecessary. Even a slight cloudy appearance does no harm.

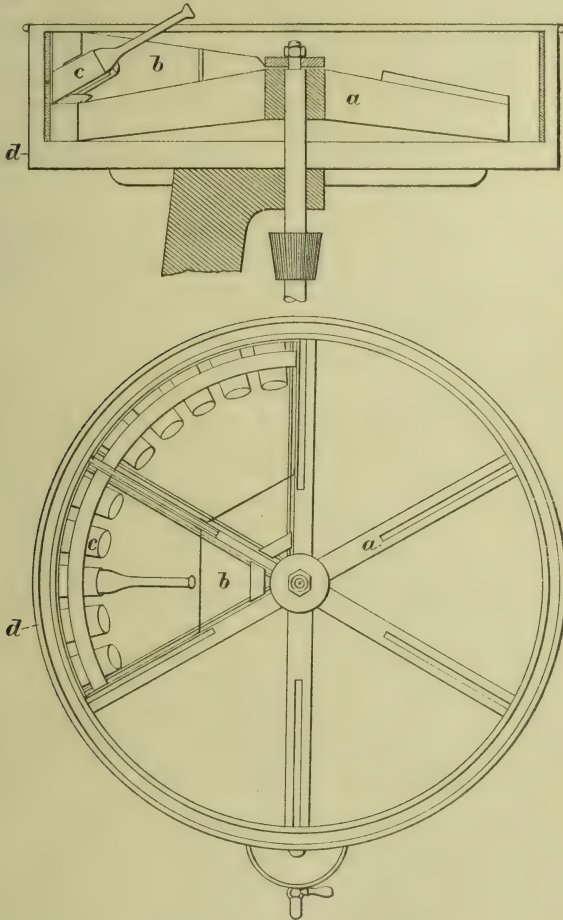


Fig. 5.

Measuring the fat.—The fat when measured should be warm enough to flow readily, so that the line between the acid liquid and the column of fat will quickly assume a horizontal position when the bottle is removed from the machine. Any temperature between 110° and 150° F. will answer, but the higher temperature is to be preferred. The slight difference in the volume of fat due to this difference in temperature is not sufficient to materially affect results. A difference in temperature of 40° F. will make less than one-tenth per cent difference in milk containing 5 per cent of fat. To measure the fat, take a bottle from its socket, and holding it in a perpendicular position

with the scale on a level with the eye, observe the divisions which mark the highest and lowest limits of the fat. The difference between these gives the per cent of fat directly. The reading can easily be taken to half divisions or to one-tenth per cent.

If the column of fat is less than about one division, as will sometimes happen with skim milk, buttermilk, or whey, it may assume a globular form instead of a uniform layer across the tube; when this occurs the fat can usually be estimated with sufficient accuracy by simple inspection, but if an accurate reading is desired it may be obtained by taking four samples of the milk in four test bottles, and after treating them in the usual way, until the bottles are ready to be filled with water, adding water to three of them only, filling them as full as possible without running them over. After whirling them for a minute to bring the fat all into the neck, the fat may be poured off from these three tubes into the fourth. If any fat remains adhering to the sides of these tubes, they should be filled a second time with water and the remaining fat poured into the fourth bottle, which is then filled with water, whirled and the reading taken; this divided by four will give the per cent of fat.

A better way would undoubtedly be to have a special test bottle, holding three or four times as much as the ordinary bottle, that could be used for skim milk, buttermilk, and whey. Three or four times the usual test sample could then be taken, and by adding the proper quantity of acid, the test could be made without transferring the fat.

Cream.—The chief difficulty in testing cream lies in the sampling. Cream that is sour, or that has been exposed to air until the surface has dried, can not be accurately sampled. The same is true of centrifugal cream that is badly frothed. Sweet cream, from Cooley cans, that is not too thick to flow readily from the pipette, may be tested with satisfactory results. The process, however, must be modified slightly from that used with milk, as the amount of fat in cream is so large that it can not be measured in the ordinary test bottle if the usual quantity is taken for the test, besides a much greater error results from the cream which adheres to the pipette than with milk. Both of these difficulties may be overcome by taking two or three test bottles and dividing the test sample into as nearly equal portions as can be judged by the eye. The pipette is then filled with water and this is run into the tubes in the same way as the cream. If three bottles are taken the pipette is filled with water a second time and emptied into the bottles as before. This serves to rinse the cream from the pipette, and at the same time to dilute it to a point where it can be tested in the same way as milk. The bottles are then treated in the usual manner, and the reading of the tubes added together for the per cent of fat in the cream.

Owing to the low specific gravity of cream, the test sample, if of the same volume, will weigh less than that of milk, and consequently the per cent of fat as shown by the scale will be less than is found by gravimetric analysis, in proportion as the weight is less than 18 grams. Where a delicate balance is available, this error may be entirely avoided by weighing the cream used in a test, and calculating the per cent of fat by multiplying the scale reading by $\frac{18}{a}$, a being the weight of cream taken.

If 17.6 cubic centimeters of cream is taken, and the portion adhering to the pipette is rinsed into the test bottle, a close approximation of the true result may be obtained without weighing by correcting the scale reading as follows: For a scale reading of 20 per cent, add 0.25 per cent; for a scale reading of 15 per cent, add 0.1 per cent. Readings between these may be corrected in proportion. Below 10 per cent no correction is necessary.

Accuracy of test.—During the past month a considerable number of comparative analyses have been made by the gravimetric method and by the new test. These are given in the following table, and show the substantial accuracy of the method. The figures are not selected, but represent all of the samples of milk analyzed by both methods between May 27 and July 15. The gravimetric analyses were made by drying the milk upon asbestos and extracting with ether. In analyses by the new test no readings were made to less than one-half a division of the scale, or to 0.1 per cent.

The figures in the second decimal place are derived from corrections for the quantity of milk used in the test, 15 and 20 cubic centimeters of milk having been taken in many of the preliminary trials. These comparative analyses were mostly made with milks from single cows, as such present greater difficulties than mixed milk.

Comparative results by the new and gravimetric methods.

[Per cent of fat.]

Kind of milk.	By new test.	By gravimetric analysis.
Single cow, Bunn; grade, Holstein.....	3.64	3.72
Skim milk.....	0.20	0.21
Single cow, Bessie's heifer, $\frac{1}{8}$ Jersey.....	6.44	6.55
Single cow, Mattie; grade, Holstein.....	3.63	3.60
Single cow, Topsy; grade, Holstein.....	3.35	3.33
Cream.....	22.98	22.69
Single cow, Bunn; grade, Holstein.....	3.29	2.99
Single cow, Rose; grade, Jersey.....	3.93	4.00
Single cow, Sylvia's heifer; high grade, Jersey.....	4.57	4.73
Single cow, Doubtful; high grade, Jersey.....	4.98	4.91
Cream.....	21.25	21.47
Single cow.....	3.75	3.87
Mixed milk.....	4.69	4.77
Single cow, Flossie; registered Jersey.....	5.31	5.38
Single cow, Bessie; high grade, Jersey.....	5.08	5.14
Single cow, Nettie; high grade, Jersey.....	5.32	5.40
Single cow, Daisy; grade, Jersey.....	4.69	4.56
Single cow, Rose; grade, Jersey.....	5.39	5.37
Mixed.....	5.98	5.94
Single cow, Jersey.....	6.91	6.87
Whey.....	0.68	0.61
Cream.....	17.96	18.08
Skim milk.....	0.89	0.81
Single cow, Bessie's heifer, $\frac{1}{8}$ Jersey.....	6.95	6.81
Single cow, Sylvia; grade, Jersey.....	6.44	6.43
Single cow, Dolly; grade, Jersey.....	5.75	5.64
Single cow, Bryant; grade, Jersey.....	4.22	4.24
Single cow, Daisy; grade, Jersey.....	4.69	4.70
Single cow, Bunn; grade, Holstein.....	2.87	2.93
Single cow; grade, Jersey.....	4.10	4.03
Single cow, Daisy's heifer; grade, Jersey.....	4.22	4.02
Single cow, Galena; high grade, Jersey.....	4.45	4.31
Single cow, Topsy; grade, Holstein.....	3.40	3.23
Single cow, Mattie; grade, Holstein.....	3.28	3.41
Single cow, Annie Johnson; registered Jersey.....	5.04	5.10
Single cow, Annie Johnson; registered Jersey.....	5.16	5.22
Buttermilk, sweet cream.....	3.00	3.09
Cream.....	16.10	16.13
Buttermilk, sour cream.....	0.40	0.58
Buttermilk.....	1.40	1.63

Applications of the method.—The test gives good results not only with milk and cream, but also with the waste products, skim milk, whey and buttermilk, so that those using it can easily watch their work and determine where and what the losses are.

To those who have facilities for weighing, it offers a rapid and quite accurate method for the estimation of fat in condensed milk and in cheese. For the examination of condensed milk about 8 grams may be weighed into a test bottle, then after adding about 10 cubic centimeters of water, the test may be conducted in the same way as with milk, the per cent of fat being obtained by multiplying the reading by 18, *a* being the weight of substance taken for the test.

a

For the estimation of fat in cheese, about 5 grams should be weighed in a small beaker, and from this transferred, as completely as possible, to a test bottle; the beaker is then rinsed into the test bottle with a mixture of 15 cubic centimeters of water and 18 cubic centimeters of acid. By shaking the bottle for a short time the curd will all be dissolved, leaving the fat free. The test is then made as with milk, the per cent being obtained in the same way as with condensed milk.

Several tests have been made with both condensed milk and with cheese, which have given a clear separation of fat. The only comparisons with the gravimetric method are the following:

Analysis of condensed milk and cheese.

[Per cent of fat.]

	New Method.	Gravimetric.
Cream cheese.....	57.05	56.80
Condensed milk.....	9.65	9.47
Cheese.....	34.87	35.46
Cheese.....	33.73	33.77

Time required for making the test.—On account of the large number of tests which may be carried along together and the little attention which each demands, the average time required for a test is very small. Two samples of milk may be tested in duplicate in fifteen minutes, including all of the work from the mixing of samples to the cleaning of the bottles. After the milk has been measured, sixty tests may be made in less than two hours, including the cleaning of the bottles.

Expense of the test.—The cost of the test will depend upon the price of commercial sulphuric acid. The wholesale price of this acid is about 2 cents per pound. At retail it can be bought at from 3 to 5 cents, according to the quantity obtained. One pound of acid is sufficient for fourteen tests. In a factory where acid is purchased by the carboy, it should not cost more than one-fifth cent per test, and in no case should it cost more than one-half cent per test.

The breakage of bottles, if properly made, is so slight that it need not be considered. We have made upwards of two thousand tests, in which only fifty bottles have been used, and only one of these bottles has been broken. The chemicals do not act upon the glass, and the bottles are only broken by accident or careless handling.

Cleaning the test bottles.—The bottles should be emptied while hot and afterwards rinsed twice with hot water; they are then ready for another test. In emptying the bottles they should be inverted and given a circular motion, which causes the liquid to form a whirlpool and allows air to enter continuously in the center of the tube; in this way the bottles may be emptied and cleaned rapidly without leaving fat attached to their sides.

Further precautions.—The sulphuric acid used should be kept out of reach of all persons except those making the test, and great care should always be taken in handling it as it is very corrosive.

If the fat does not separate clear from the acid liquid when water is added to bring it into the neck, it indicates that the acid used is too weak and more should be used. If the fat separates clear from the acid, but is blackened, it shows that the acid is too strong, and it should be diluted to a specific gravity of 1.82 before using, or a little less of the acid could be used for the test.

It sometimes happens in testing buttermilk that is quite sour, that the addition of water to bring the fat into the neck of the bottle where it can be measured causes a precipitate of casein or other matter, which mingles with the fat and prevents an accurate reading. This difficulty has also occurred a few times with milk that had stood a considerable time before testing; it may be entirely avoided by filling the bottles with a hot mixture of equal parts of sulphuric acid and water instead of water alone.

The greatest source of error is in the graduation of the tubes, and no one should purchase tubes except from reliable parties who will guaranty their accuracy.

The apparatus is now supplied in several sizes by Messrs. Cornish, Curtis & Greene, Fort Atkins, Wis.

The average differences between the results of twenty-nine comparative analyses made both by this method and by the gravimetric method is 0.08 per cent. The maximum differences are + 0.20 and — 0.16 per cent.

In Bulletin No. 19, new series, New York Experiment Station, June, 1890, tests are reported of Parsons's method of determining fat in milk (first annual report New Hampshire Experiment Station). The results differed too widely from those obtained by the gravimetric method. But when 15 cubic centimeters of soda solution and 10 cubic centimeters of alcoholic soap solution were employed, the agreement with the gravimetric method was satisfactory. A minute description of the apparatus and details of the method is given *loc. cit.*

Penney (report Delaware Experiment Station, 1889, 168) reports tests of the efficiency of the lactocrite and Cochran's method of determining fat in milk, comparing each with Soxhlet's areometric method. The results of twenty-two trials with the lactocrite show extreme deviations from Soxhlet's method of -0.8 per cent and $+0.7$, the mean deviation being 0.3 . Thirteen out of twenty-two trials agreed fairly well with the standard.

Manns (Illinois Experiment Station, Bulletin No. 9) compares the results obtained by Short's method of determining fat in milk with the "gravimetric" method. In sixteen trials the average per cent of fat by the gravimetric method was 3.71 ; by Short's method, 3.78 , and by a lactoscope method, 3.65 . The extreme variations by Short's method were $+0.23$ and -0.22 per cent. By the lactoscope method, $+0.44$ and -0.53 .

He also compared the pounds of butter fat found by Short's method in the milk supplied by a considerable number of dairy patrons with the pounds of salted butter obtained by the churn. The average difference between the two methods was 1.41 per cent of the quantity found by Short's test. The widest deviations were $+5.96$ and -3.85 per cent. He concludes that the Short method is trustworthy, and gives results agreeing quite well with the actual churn yield. It could well be used as a standard test in paying for milk by its actual butter value.

Farrington (Illinois Experiment Station, Bulletin No. 10) made a number of comparisons of the gravimetric method of determining fat, with the methods of Short, Parsons, Failyer & Willard, Cochran, and Patrick. The results were as follows:

	Gravimetric method.		Patrick.	Cochran.	Short.
	On sand.	On paper.			
Herd milk.....	{ 3.09 3.11 .....	..... ..... ..... .....	3.12 3.05 3.08 3.00 .....	..... ..... ..... .....	..... ..... ..... .....
Average	3.09		3.06		
One cow.....	{ 4.59 4.46 .....	..... .....	4.50 4.80	4.67 4.50 .....	..... .....
Average	4.52		4.65	4.58	
One cow.....	{ 3.70 3.77 4.33 4.78 4.13	3.60 3.78 4.28 4.80 4.06	3.70 3.70 4.20 4.70 4.10	3.60 3.76 4.15 4.67 3.97 .....	..... ..... ..... ..... .....
Do	{ 4.69 4.71	 4.58 4.59	4.60 4.55 4.69 4.60	 4.50 4.55 4.67	4.78 4.88 4.88 4.88
Average	4.70	4.59	4.59	4.57	4.85
One cow.....	{ 3.88	 3.96	4.00 4.00	3.97 4.15	3.86 3.97
Average			4.00	4.03	3.91
One cow.....	{ 4.30	 4.40	4.20 4.20	4.15 4.15	4.68 4.58
Average			4.20	4.15	4.63

	Gravimetric method.		Patrick.	Cochran.	Short.
	On sand.	On paper.			
Skim milk:					
Laboratory No. 234.....	{ 0.57	0.80	0.80	0.69 .....	.....
	{ 0.62	0.80	0.80	0.69 .....	.....
Average	0.59	0.80	0.80	0.69 .....	.....
Laboratory No. 241.....	0.48	0.48	0.60	0.48 .....	.....
Laboratory No. 242.....	{ 0.66	0.70	0.70	0.69 .....	.....
	{ *0.68	0.70	0.70	0.69 .....	.....
Laboratory No. 250.....	{	0.94	0.80	0.79 .....	.....
	{ 0.94	0.97	0.80	0.79 .....	.....
Laboratory No. 252.....	{	1.40	1.40	1.12	1.12
	{	1.30	1.30	1.27	1.12
	{ 1.23	1.28	1.30	1.38	1.12
	{ 1.52	1.30	1.30	1.27	1.12
Average	1.38	1.32	1.32	1.31	1.12
Laboratory No. 261.....	.....	1.88	1.90	1.90	1.88
Buttermilk:					
Laboratory No. 235.....	{ 0.37	0.00	0.00	0.34 .....	.....
	{ 0.37	0.00	0.00	0.34 .....	.....
Laboratory No. 239.....	{	0.00	0.00	0.00 .....	.....
	{ 0.46	0.47	0.35	0.32 .....	.....
Laboratory No. 249.....	{	0.87	0.00	0.00 .....	.....
	{ 0.81	0.90	0.60	0.93	0.80
Laboratory No. 253.....	{	0.39	0.20	0.34 .....	.....
	{ Lost	0.40	0.20	0.34 .....	.....
Laboratory No. 258.....	{	0.50	0.50	0.69	0.40
	{	0.96	0.50	0.69	0.40

*Asbestos.

Lezé (Compt. rend., 1890, 110, 647; abstr. Chem. Zeitg. Repert., 1890, 109) determines fat in milk as follows:

Into a flask with a narrow neck graduated to tenths of centimeters, bring 100 parts of milk and 200 to 250 parts of pure concentrated hydrochloric acid. Heat till the solution is brown and add dilute ammonia till it clears. Then fill the flask with hot water till the surface of the liquid is at the 0 mark on the scale and then read off the volume of the fat. Since fat at its melting point has a specific gravity of 90, the volume is to be multiplied by this factor to obtain the weight.

Gorodetzky (Aus dem städtisch. Untersuchungs-lab. von Prof. A. Werigo zu Odessa, abstr. in Zeitschr. f. angewand. Chem., 1890, 418) has made twenty-nine analyses of milk for the comparison of Röse's method of determining fat with the usual sand extraction method and in some cases with Soxhlet's areometric method.

The author found five hours' time sufficient in nearly every case for the extraction of fat by the sand method; three hours' time was in many cases insufficient.

The comparison of the sand method, Röse's method, and the areometric method is given as follows:

Differences between the several methods.

	Röse's and sand method.			Sand and areometric method.			Röse's and the areo- metric method.
	Time of extraction.			Time of extraction.			
	3 hours.	5 hours.	7 hours.	3 hours.	5 hours.	7 hours.	
Maximum	+0.195	+0.195	+0.128	+0.112	+0.112	+0.115	+0.212
Minimum	-0.022	-0.060	+0.020	-0.053	-0.022	0.021	+0.015
Average	+0.079	+0.037	+0.063	+0.017	+0.050	+0.015	+0.081

The experiments were apparently conducted with the greatest care, and the author gives particular description both of the methods and of the manipulation.

F. Walls (Chem. News, 61, 162) proposed a method of determining fat in milk, in which a tube containing asbestos is substituted for Adams's paper coil. The method does not differ essentially from the one proposed and used by Babcock.

F. Ballario and C. A. Revelli (Le Staz. Speriment. Agrar. Ital., 18, 113; Abstr. in Vierteljahresschr. Nahrungs u. Genussmittel, 1890, 5, 20) have made a long series of experiments to test the methods of fat determination by the lactobutryrometer and determination of solids by reckoning from the specific gravity and fat.

(1) *Determination of fat*.—Girard's method of using the lactobutryrometer was adopted, except that 20 cubic centimeters of alcohol ether-ammonia mixture were brought into the instrument first, and 10 cubic centimeters of milk were quickly added and shaken. The readings were made at 20° C. In reckoning the fat, both the tables of Tollens and Schmidt and those of Marchand were tested. The results were compared with those by Soxhlet's areometric method. The authors conclude that the instrument, used according to their directions, will give accurate results with milk containing between 1.3 and 4.5 per cent of fat.

(2) *Determination of total solids*.—The authors again call attention to the fact that the milk must be kept in a refrigerator, 6° to 8° C., for about sixteen hours before attempting to determine the specific gravity, then brought to a temperature of about 20° C. and the specific gravity determined.

The solids were determined by drying 5 cubic centimeters in a platinum dish without the addition of sand, to constant weight, which usually required three hours. Better agreement between the solids calculated and found was obtained by the use of Fleischmann and Morgen's formula than by using Fleischmann's newer formula. The authors find that the per cent of solids calculated agrees sufficiently with that analytically determined, and that neither skimming nor watering the milk renders the method less accurate.

J. C. Shenstone (Analyst, 13, 222) describes in detail his method of determining milk sugar and cane sugar in condensed milk. This has already been outlined in the Proceedings of the Sixth Annual Convention of Association of Official Agricultural Chemists, 1889, page 149.

Sugar determination in milk.—M. Kühn (Milch Zeitg., 1889, No. 47,925) has compared the methods of Tollens, Soxhlet and the polarimetric method (precipitation of the proteids) with acetic acid and sugar of lead as modified by Schmöger or with phospho-tungstic acid.

In using Tollens's method he employed 100 cubic centimeters of the sugar solution, 30 cubic centimeters water, and 40 cubic centimeters of Fehling's solution, boiled six minutes in an Erlenmeyer flask, filtered on asbestos, and reduced the copper oxide in hydrogen. $\text{Cu} \times 0.763 = \text{sugar}$. In using Soxhlet's method he followed Fres. Quant. Anal., 6 Aufl., II Bd., 601; boiling for six minutes and then proceeding as above.

In using the polarimetric method, casein was first thrown down by acetic acid, and in the filtrate the remaining proteids were precipitated with sugar of lead or with phospho-tungstic acid.

The averages of twenty-one different analyses by the several methods are as follows:

	Per. cent.
Tollens	4.596
Soxhlet.....	4.623
Polarimetric:	
Using sugar of lead	4.679
Using phospho-tungstic acid	4.768

The results by the phospho-tungstic method were in some cases very considerably higher than by the other methods. The author holds in opposition to Schmöger that the phospho-tungstic method is not the most reliable, and for the present holds to Soxhlet's, Tollens's method requiring more time for its execution.

Cochran's method.—As the right to use this method is claimed to be covered by a patent, it is not further noticed here. The patentee will doubtless give all necessary particulars.

REPORT ON DAIRY PRODUCTS.

The following report relates exclusively to butter, and concerns only the determination in it of water, fats, casein, salt, and other mineral matters. It is designed to supplement the coöperative work of the association last year, which consisted in determining the volatile acids, specific gravity, melting point, etc., of butter fats; data which serve to detect the presence of foreign fats in butter.

It is very clear that a strict comparison of the "butter records" of individual cows or herds can only be made when the composition as well as the gross weight of the butter yield is known.

A cow that is giving in a fixed period 20 pounds of butter which carries 15 per cent of water is making a better "record" but is not producing as much butter fat as another cow that gives 19 pounds of butter in the same period with 9 per cent of water. When butter is worked honestly and carefully the water content of different churnings will vary considerably, and with a little manipulation can be made to hold from 15 to 18 or 20 per cent of water. A uniform and accurate method of butter analysis is therefore highly desirable.

The subject seems to have been rather slighted by writers on agricultural analysis, and some of the methods proposed in standard works could certainly never have been successfully used by their authors or any other man.

Grandean (*Traité d'Analyse des Matières Agricoles*, 12th ed., 1883, 175) directs to determine water by drying about 20 grams of butter in a test tube on a water bath or in an oven to a constant weight. Fat is determined by dissolving in ether the residue from the water determination, filtering on a warm filter and washing with ether. A fraction of the filtrate is evaporated, dried, and weighed. The insoluble residue left on the filter, consisting of casein, sugar, salt, and other mineral matter, is washed with water, the washings are evaporated to dryness and if this gives any residue insoluble in water it is added to the contents of the filter, which are then dried, weighed, and incinerated. The difference in dry weight of the residue before and after incineration represents the casein. In the aqueous solution the total mineral matter, the sugar (by titration), and the salt are determined.

Böckmann (*Chemisch-technische Untersuchungsmethode*, II, 608) prefaces the details of his method of analysis with the remark that it presents no difficulty. Water is determined in 50 to 80 grams by heating at 100° to 110° till constant weight is secured, and fat is determined by extracting from 5 to 6 grams of the dried butter in an extraction apparatus. The residue from the extraction is collected on a weighed filter, dried, and weighed. It is then incinerated in a weighed platinum dish. Casein and milk sugar are thus determined by difference, and mineral matter by direct weighing. If the sugar is to be determined another portion of the dried butter is extracted with ether and the residue washed with water slightly acidulated with acetic acid on a weighed filter. Milk sugar is dissolved while casein and part of the mineral matter remains. This is dried and weighed on the filter. After incineration the weight of the ash is determined and deducted, thus giving the casein by loss of weight. Milk sugar is determined by subtracting the quantity of casein found in this operation from the sum of milk sugar and casein previously obtained.

Fleischmann, (*Molkereiwesen*, 588) weighs from 5 to 10 grams of butter into a small weighed beaker and after melting decants the clear fat into a weighed filter and funnel, receiving the filtrate in a weighed flask. All these vessels with the fat are dried at 100° C. and water is calculated from loss of weight. The residue is then brought into the filter with ether and washed till the fat is completely extracted. After distilling off the ether the flask with the fat is dried and weighed.

Mineral matter is determined by incinerating the residue left on the filter. From

100 grams of butter the fat is extracted and a nitrogen determination in the residue gives by calculation the quantity of casein.

These abstracts give a fair idea of the methods at present recommended for the analysis of butter.

WORK OF THE ASSOCIATION, 1889-'90.

PREPARATION OF THE SAMPLE FOR COÖPERATIVE WORK.

The method of preparing the sample is essentially that practiced by Mr. Babcock, of the Wisconsin Station. The sample which was sent to members of the association was fresh Connecticut creamery-made butter. A pound of this butter was heated slowly in a closed pint jar till just melted, then shaken violently for some minutes and quickly poured into tubes closed at one end with corks. These tubes were at once stoppered, brought to a cool place and kept in motion (turned end over end and also on their longer axes) till the butter solidified, which required only a few minutes. All the constituents were then determined in duplicate in the first tube filled, and single determinations were also made in the tube filled last, with the following results:

	First tube.			Last tube.
	1.	2.	Average.	
Water, 1½ hours at 100° C.....	12.94	12.82	12.88	12.90
Water, 4 hours at 100° C.....	12.96	12.86	12.91	12.92
Casein and ash.....	6.46	6.48	6.47	6.49
Casein.....	1.39	1.34	1.36	1.27
Ash.....	5.07	5.14	5.11	5.22
Salt.....	5.00	5.11	5.05	5.23
Fat.....			80.62	80.59

These figures indicate that the contents of the tubes were nearly if not quite uniform in composition.

The tubes were then sent to a considerable number of stations, those being selected which were believed to be most engaged in dairy work. With each sample was also sent a proposed scheme of analysis with the request that the sample should be analyzed by that method and also for comparison by any other which seemed to the analyst preferable.

Following is the scheme:

PROPOSED METHOD OF BUTTER ANALYSIS.

To remove from the tube portions of the sample herewith sent for analysis, remove both corks and insert at one end a smaller cork that will readily pass through the tube. By pushing this with a rod the cylinder of butter is pressed out at the other end and may be cut off as wanted.

Water.—About 2.5 grams, accurately weighed, are dried in an air-bath at the temperature of boiling water until constant weight is secured. The dish used for the purpose must have a flat bottom of 3 or 4 square inches surface.

Fat, casein, and ash.—The dried butter from the water determination is treated in the dish with 76° benzine and stirred till the lumps disappear. The contents of the dish are then transferred, with the aid of a wash bottle filled with benzine, to a weighed Gooch crucible and washed till free from fat. The crucible and contents are dried at 100° for two hours and weighed. This weight, less the weight of the crucible, represents the casein and ash; and the difference between this and the dried butter represents the butter fat. The crucible is then ignited carefully, below a red heat, and weighed again. The loss in weight represents casein, the remainder mineral matter, chiefly salt.

RESULTS OF ANALYSIS.

One or two tubes broke in transit and several chemists were unable to do the work requested. In the following table are arranged the results obtained by eleven different chemists in nine laboratories.

The following chemists participated in the work: Maine Experiment Station, Messrs. Jordan, Bartlett and Merrill; Cornell Experiment Station, Mr. W. P. Cutter; Illinois Experiment Station, Mr. E. H. Farrington; Texas Experiment Station, Messrs. H. H. Harrington and W. Wipprecht; Wisconsin Experiment Station, Mr. S. M. Babcock; Kentucky Experiment Station, Messrs. W. A. Scovell and A. M. Peter; U. S. Department of Agriculture, Mr. Aug. E. Knorr; Pennsylvania Experiment Station, Mr. G. L. Halter; Connecticut Experiment Station, Mr. A. L. Winton, jr.

	Maine Experiment Station.		Cornell Experiment Station.	Illinois Experiment Station.	Texas Experiment Station.		Wisconsin Experiment Station.	Kentucky Experiment Station.	U. S. Department of Agriculture.	Pennsylvania Experiment Station.	Connecticut Experiment Station.
	B.	M.			H.	W.					
Water ...	Dup. 12.86	Dup. 12.71	Dup. 13.02	12.86	12.64	12.71	Dup. 12.79	Dup. 12.78	Dup. 12.76	Dup. 12.72	Dup. 12.88
Casein ...	1.30	1.11	1.95	1.32	.88	1.12	1.18	1.26	1.37	1.49	1.37
Fat ...	80.80	81.08	80.02	80.75	81.90	81.51	80.96	80.93	†81.14	81.07	80.64
Ash (salt)	5.04	5.10	5.01	*5.03	4.58	4.66	5.07	5.01	4.73	4.67	†5.11
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	100.00	99.95	100.00

	A.	B.	C.	D.
Water.....	Dup. 12.80	[12.80]	Dup. 12.86	Dup. 12.83
Casein.....	1.07	1.24	1.50	1.56
Fat.....	81.02	80.76	80.68	80.37
Ash (salt).....	5.11	5.09	†4.97	5.24
	100.00	99.89	100.01	100.00

* 4.94.

† 5.05.

† 4.95.

NOTES BY ANALYSTS.

Mr. Scovell could not get a constant weight in less than five and one-half hours when he used *round*-bottomed dishes 3 inches in diameter.

Thus the loss of moisture in two hours was 6.4 per cent; in three hours 8.4; in three and one-half hours 11.1; in five and one-half hours 12.7.

When he substituted a *flat*-bottomed dish 1½ inches in diameter, two hours' drying sufficed.

Mr. Scovell also determined water by weighing the butter into a weighed dish containing asbestos and drying at 105° C. in an oil oven to constant weight. The contents of the dish were then transferred to a Soxhlet's apparatus and extracted with Squibb's ether, and the fat was dried at 100° to constant weight. Another portion was washed with hot water several times and salt determined by standard silver solution (analysis A in the table). In another sample the asbestos, after extraction of fat, was returned to the dish, carefully dried at 105°, and reweighed, and thus fat was determined by difference; casein was determined by loss on subsequent ignition and ash from the residue. (Analysis B in the table.)

Mr. Jordan reports that in the water determination three and one-half hours' drying were necessary to secure constant weight.

Mr. Cutter reports the drying as tedious. He prefers to use sand to absorb the butter for drying, determines ash in a separate portion, and casein by difference, or by a nitrogen determination by the Kjeldahl method.

Mr. Farrington found that the shape and size of dish made a great difference in

the time required for evaporation of the water in butter, and he got a constant weight quickest by using asbestos in the dish with the butter. Using ether instead of benzene for dissolving the fat (otherwise following the proposed method), he got the results given in Analysis C.

By extracting the residue left on asbestos, after determining water in a Soxhlet extractor and weighing the extracted fat, he got in duplicate determinations 80.47 and 80 per cent of fat, while by the indirect determination he got 80.75 and 86.68 per cent.

Mr. Babcock prefers to dry the butter on asbestos, extract the fat and weigh it directly. He states that the direct weighing gives him on the average 0.25 per cent more fat than the indirect method. He says: "I at first supposed that this difference was due to ether remaining in the fat, but do not think so now. I have added ether to pure butter fat, and after evaporating it in the same way as in my analyses have found the weight practically the same as at first. The error due to oxidation of fat while drying is very slight. In butter and milk analysis we dry the fat in a vacuum oven under diminished pressure. This greatly diminishes the time required and gives more uniform results. The fat-free residue from either butter or milk appears to be either quite hygroscopic or easily oxidized, as results by difference rarely gave as close difference as direct weighing, while with me they have been uniformly lower." He determines ash in a separate portion and curd by difference. Where curd is determined by $N \times 6.25$ he always finds from 0.2 to 0.5 excess (over 100 per cent). An analysis made in this way is marked D in table.

At the Connecticut Station, in numerous tests, Mr. Winton found the method of drying without sand or asbestos at 100° in an open dish perfectly satisfactory, *provided the surface exposed was sufficient* and the layer of butter not too deep. A surface of 3 to 4 square inches for $2\frac{1}{2}$ grams of butter made it possible to complete the drying in two hours.

It has been proposed to weigh casein and ash together after removing water and fat as follows: The butter in a weighed Gooch crucible is placed in the water bath on bibulous paper. The water evaporates and at the same time the fat is drawn out by the blotter. It then only needs a slight washing with benzene to remove the last traces of fat, and casein and ash alone remain. Working in this way Mr. Winton got casein and ash 6.22 and 6.26, instead of 6.46, 6.48, and 6.49 by the other method. The casein was 1.28 and 1.31, instead of 1.34, 1.39, and 1.27 by the other method. Here is a loss of 0.23 per cent, falling chiefly on the ash, and due no doubt to the fact that water also passes out to the blotter with the fat, carrying salt with it.

Mr. Winton found no advantage in using sand in the determination of water.

Thus, when dried without sand for two hours the sample lost 12.77 per cent of water; when dried with sand for the same time it lost 12.80 per cent. If the dishes used are too small or of unsuitable shape, the addition of sand or asbestos facilitates drying.

The following additional water determinations were made, all in platinum dishes of the size and shape recommended in the scheme of analysis.

Temperature 100° , time of drying one and three-quarter hours, per cent of moisture 12.94, 12.82, and 12.90. Temperature 100° , time of drying three hours, per cent of moisture 12.96, 12.86, and 12.92. Temperature 105° , time of drying two hours, per cent of moisture 12.77. Temperature 105° , time of drying two hours, per cent of moisture 12.77.*

DISCUSSION OF THE RESULTS.

The average of all the analyses made by the prescribed method is as follows:

Water	12.79
Casein	1.31
Fat	80.99
Ash	4.91
	100.00

*Dried with sand.

Water.—The extremes in the several determinations of water differ by 0.38 per cent. Two out of the eleven differ from the average of all by more than 0.15 per cent.

Casein.—The extreme difference between the several determinations is 1.07 per cent, and five differ from the average, by more than 0.15 per cent.

Fat.—The extremes in the fat determination differ by 1.88 per cent. Six of these differ from the average of all by less than 0.20 per cent. Three others are not more than 0.5 per cent from the average, and three determinations are "wide."

Ash.—The extremes in ash determinations are 0.53 per cent apart. Five of them are within 0.15 per cent of the average, and three more are within 0.20 per cent.

The water determinations are quite satisfactory. It appears to your reporter doubtful whether, if the method and manipulation were faultless, results could be expected to agree much more closely than those herewith reported, considering the difficulty of preparing a sample for analysis which shall be perfectly homogeneous. The results are sufficiently close for any present demand. The extreme difference between the highest and lowest determinations would amount to a difference of only 6.4 ounces on 100 pounds of butter.

There is room for improvement in the determination of the other ingredients. The dangers which beset the method are :

- (1) Volatilization of salt by overheating when casein is burned off.
- (2) Mechanical loss at the same time by decrepitation of salt. The crucible should be covered when the heat is first applied.
- (3) The residue, consisting of casein and salt, is said to be quite hygroscopic, and needs to be carefully dried and quickly weighed.
- (4) If ether is used instead of benzine to dissolve the fat, it will dissolve part of the salt also unless the ether is perfectly anhydrous.

In conclusion your reporter recommends the adoption by the association of the following

METHOD FOR THE ANALYSIS OF BUTTER.

Sampling.—If large quantities of butter are to be sampled a butter tryer or sampler may be used. The portions thus drawn are to be perfectly melted in a closed vessel at as low a heat as possible, and when melted the whole is to be shaken violently for some minutes till the mass is homogeneous. A portion is then poured into a vessel, from which it is to be weighed out for analysis and should nearly or quite fill it. This sample should be kept in a cold place till analyzed.

Determination of water.—1.5 to 2.5 grams are dried to constant weight, at the temperature of boiling water, in a dish with flat bottom having a surface of at least three square inches.

The use of clean dry sand or asbestos with the butter is admissible, and is necessary if a dish with round bottom is employed.

Determination of fat.—The dry butter from the water determination is dissolved in the dish with absolute ether or with 76° benzine. The contents of the dish are then transferred to a weighed Gooch filter with the aid of a wash bottle filled with the solvent, and are washed till free from fat. The crucible and contents are heated at the temperature of boiling water till the weight is constant. The weight of the crucible and contents deducted from the weight of the dried butter gives the quantity of fat present.

Substitute method for fat.—Water may be determined by drying the butter on asbestos or sand, and the fat extracted by *anhydrous, alcohol-free* ether in an extraction apparatus. The extract, after evaporation of the ether, is heated to constant weight at the temperature of boiling water and weighed.

Determination of casein and ash.—The crucible containing the residue from the fat determination, consisting of casein and ash, is covered and heated gently at first, gradually raising the temperature to just below red heat. The cover may then be removed and the heat continued until the contents of the crucible are white. The

loss in weight of the crucible and contents represents casein, and the residue in the crucible mineral matter. In this mineral matter, dissolved in water slightly acidulated, chlorine may be determined gravimetrically with silver nitrate.

Mr. McDonnell asked what was meant by "76° benzine," referred to in the recommendation as to determination of fat.

Mr. Stubbs said that it meant benzine which flashed into vapor at 76°; that was the way he bought it.

Mr. Myers said that it was a commercial term.

Mr. Terne said that 76° Baumé was meant.

Mr. McDonnell said that he had not been aware that Baumé lighter than water ran up to 76°.

Mr. Wiley said that it did not run up; it ran down.

Mr. Stubbs said that he was rather certain about the meaning; that it was as he had stated. He used a great deal of benzine and gasoline, using gasoline whose flashing point was 77° and benzine that flashed at 76°. Kerosene oil flashed at 120°; he felt sure that the recommendation referred to the temperature at which the benzine vaporized and flashed.

Mr. Myers said that when he had received from Mr. Jenkins the samples of butter and directions for making the analyses he had been puzzled by the term "76° benzine," and had written to inquire its meaning. Mr. Jenkins had replied that it was a commercial term for a particular grade of benzine. The speaker did not now know, nor did he care, whether the reference was to the flashing point or to the specific gravity; the title under which the article was sold was "76° benzine."

The president said that his gasoline was purchased from the Standard Oil Company; he bought it from 76° to 87°, and tested it by Baumé to make sure that it was right.

Mr. Terne said that he bought three or four carloads a month, buying it all by degree of Baumé.

Mr. McDonnell said that, being puzzled by the point, he had looked through all his chemical books, but could find no degree of Baumé to correspond with 76.

Mr. Lupton moved that the report on dairy products, together with the method recommended by Mr. Jenkins for butter analyses, be adopted as read. Seconded.

Mr. Woods inquired why, in determining the specific gravity and in estimating the volatile acids, it was necessary or advantageous to rinse a flask with alcohol and ether.

Mr. Wiley said that the specific gravity flasks were presumed to have been used before, and it was difficult to clean the fat out of such flasks with water. Ether and alcohol would remove the bodies insoluble in water, and after being washed with these the flasks could be dried more easily; the alcohol removed any water which might have been left in the flask, and the ether removed any remaining alcohol, so that in

subsequent drying the whole would be clean. This was the reason for directing that the flasks be rinsed in alcohol and ether.

Mr. Woods said that he had deemed it a piece of unnecessary labor. After cleaning his flasks with soap and water he had tested them with alcohol and ether to see whether anything more would come out; he had failed in both cases, the flasks weighing the same after the treatment as before. He had found no difficulty in cleaning with soap and water. The time and trouble involved in redistilling made it a considerable nuisance, and in the estimating of volatile acids and of specific gravity he had had, so far as he knew, no difficulty whatever.

Mr. Wiley said that it was quite difficult to remove soap from the inside of a flask if used to clean the flask; a good deal of water had to be used subsequently, and if the flasks were to be reweighed, some difficulty would be experienced in getting them dry.

Mr. Woods said that he found no difficulty in drying them out in an hour.

Mr. Wiley said that the flasks were sometimes wanted for immediate use.

Mr. Woods said that he did not understand the rinsing to be an essential part of the method.

Mr. Wiley said it was not; the direction was simply for the sake of convenience.

Referring to the report of Mr. Jenkins, in which of course he was very much interested, he was pleased to find the analyses so concordant. It seemed to him, however, that to call the method one for the analysis of butter was almost a misnomer, it being only a preliminary method to the analysis of butter.

The president said that he understood the intention was to adopt this report in connection with the last one upon the same subject.

Mr. Wiley said that the adoption of this, as a method for the analysis of butter, would eliminate some of the most important work which the association was called upon to do, namely, the distinguishing of natural from artificial butter; therefore, while he was perfectly agreed to the method recommended by the reporter for a *partial* analysis of butter, he thought it improper to call it a method for the analysis of butter, thereby implying that nothing else was to be done by the chemists of the association in butter analysis. He believed it would be proper to substitute the method proposed for similar methods in the old report, letting the rest remain for subsequent work and improvement.

The president said that there seemed to be no preliminary report; he thought that had been left out.

Mr. Cooke moved, as an amendment to the motion before the convention, that the report of Mr. Jenkins be accepted simply, the matter of adopting the method proposed to come before the association, part by part, in the regular order of business, following the plan carried out in regard to the report on nitrogen.

The president said that such a motion was unnecessary; the report was accepted by being read; its adoption was another thing.

Mr. Frear said that according to his understanding this method, if adopted, was to be used for the comparison of undoubted samples of butter, for instance, at prize shows, for the purpose of determining which cow would give the most butter; that it was not intended as a substitute for methods involving the determination of volatile acids, melting point, etc., and that this would be stated in the report.

The president said that he had taken it for granted that the present report was to be considered as an addition to the report of last year, which, containing nothing in regard to a preliminary examination of butters, went directly to their adulteration.

Mr. Lupton asked whether the report differed materially from that made last year by Mr. Wiley.

Mr. Wiley said that there was some difference in the method of estimating the salt; the proposed method was by difference in weight on ignition, which was evidently a less accurate method than the other; but the present report related principally to the sections printed on page 209 of the report for last year.

The president said that a motion to adopt the report was before the convention. A motion to substitute would be in order.

Mr. Cooke said that in the method of sampling it was stated to be necessary to keep the sample in motion while cooling after melting and pouring out; the final method should also contain that direction, for it was very essential that the sample should be shaken while cooling. It seemed somewhat strange that the association should have to adopt an indirect method for getting the fat, which was the principal thing, but the method proposed was one of indirect determination, getting the fat by difference. Any mistake in the water would make a mistake in the fat, and so would any error in the curd or salt. It would seem that the association ought to be able to find some direct method of determining the butter fat.

Mr. Farrington said that in his judgment, based upon butter analyses made by himself, the proposed method of estimating the fat was much more accurate and presented fewer difficulties in manipulation and weighing than that of extracting and weighing in large quantities. He hoped the method would be adopted.

Mr. Myers suggested that the recommendations be taken up seriatim in connection with last year's report, discussed one at a time, amended as might seem best, and then adopted as a whole.

There being no objection the president so ordered, and requested Mr. Wiley to read the recommendations in connection with the report of last year.

Mr. Myers moved that the method for microscopic examination of butter remain as it was last year (page 200). Carried.

Mr. Myers moved that the method for determining the specific gravity remain as it was last year (pages 200, 201). Seconded.

Mr. Wiley said that Mr. Knorr had made some very interesting determinations in connection with the matter of specific gravity relative to the weight of water in the flask compared directly with water at the same temperature.

Mr. Knorr said that what he had done was simply to calculate the weight of the water contained in the flasks at the temperature of 100° by the formula given in Landolt's chemical physical tables. Instead of filling the flask with hot water and allowing that to cool, he simply calculated the weight of the water.

Mr. Wiley said that comparisons had shown this method to be even more rapid than that of calculating the water contained in the flask at the temperature given from the table of constants for that purpose; a recalculation never had to be made, so that a great deal of time and labor was saved. He would like, if Mr. Knorr could put his method in shape for introduction, to have the method of last year amended so as to include it; it had been found fully as accurate as the method now in use, if not more so. A table could be inserted from which the calculation might be made for any flask.

Mr. Knorr said that it was a regular formula for calculating the weight of flasks or glass vessels.

Mr. Anderson asked whether difficulty would not arise from atmospheric differences; he had found that the weight of water differed from time to time.

Mr. Wiley said that the pressure of air was presumed to be reasonably constant. Of course with a very low barometer the water in the flask would boil at a lower temperature than with a very high barometer, for the latter would give a higher temperature and the weight of a given volume of water would be less; but the variations were so small as to introduce no appreciable error into the number for specific gravity, and, as they pertained equally to the water and the oil, the calculation made for any given locality was applicable except with a very low or a very high barometer; for all ordinary pressures they made no appreciable error.

Mr. Myers said that in this connection he would like to hear the recommendations of Mr. Jenkins in reference to determining the water.

Mr. Wiley said that the proposed amendment related only to the method for determining specific gravity, and had nothing to do with the determination of water in the butter.

The president said that he so understood.

Mr. Wiley said that the amendment proposed was the insertion, as an alternate method for determining the weight of water, its computation by the formula of Landolt.

The amendment was agreed to.

Mr. Myers moved that the method for determining the melting point remain the same as it was last year (pages 202-204). Carried.

Mr. Myers moved that the method for the estimation of volatile acids remain the same as it was last year (pages 204-207). Carried.

Mr. Myers moved that the method for determining iodine equivalent remain the same as it was last year (pages 207, 208). Carried.

Mr. Myers called for the recommendations of Mr. Jenkins.

Mr. Wiley read the first recommendation, as follows:

Sampling—If large quantities of butter are to be sampled a butter tryer or sampler may be used. The portions thus drawn are to be perfectly melted in a closed vessel at as low a heat as possible, and when melted the whole is to be shaken violently for some minutes till the mass is homogeneous. A portion is then poured into a vessel from which it is to be weighed out for analysis, and should nearly or quite fill it. This sample should be kept in a cold place till analyzed.

Mr. Wiley said that this was the point where Mr. Cooke suggested the insertion of the statement that the sample vessel also should be kept in motion until the butter was solidified. Evidently it was the idea of Mr. Jenkins that the whole sample should be taken.

Mr. Myers suggested that possibly some members of the association did not know what was meant by "butter sampler." It might be well to define it.

Mr. Wiley said that he generally used a case knife; he supposed that the sampler spoken of in the recommendation was something like the thing used in sampling sugars, a conical, hollow instrument with a slit in one side, which could be thrust into a mass of butter and withdrawn to remove a portion of it.

Mr. Cooke said that the hollow was in the form of a half circle.

Mr. Huston said that he had seen used for the purpose a brass tube cut in two lengthwise, leaving half the tube, the lower end of which was provided with a solid piece of brass flush with the cut; this made a very efficient instrument for sampling the material, the block in the end preventing any of it from slipping back.

The president said that as he understood the recommendation it was that from a large sample, taken by melting, a smaller sample was to be set apart for analysis by means of melting the butter at a low temperature.

Mr. Van Slyke inquired as to how many grams might be considered a large sample.

Mr. Wiley said that further back in the report the quantity was stated as about one pound.

A member said that it would be well to insert in the recommendation some approximately definite quantity; 10 or 20 grams might be considered a large quantity by some chemists and some might think 1 gram large.

Mr. Van Slyke said he would move that a certain number of grams be taken as the sample if some one would suggest the quantity.

Mr. Wiley suggested that about 500 grams would answer.

Mr. Van Slyke moved that 500 grams be inserted as the amount to be taken as a sample when that quantity of butter should be on hand.

Mr. Cooke asked whether it would be necessary to take the small sample from a large sample of 500 grams.

Mr. Lupton said that it might be well to make it from 100 to 500 grams.

Mr. Wiley said that the idea in saying *about* 500 grams was the impossibility of prescribing the exact amount of a sample in all cases. Amended as proposed, the recommendation would read:

If large quantities of butter are to be sampled a butter tryer or sampler may be used. The portions thus drawn, about 500 grams, are to be perfectly melted in a closed vessel at as low heat as possible, etc.

The amendment was agreed to, and the recommendation of the reporter, as amended, was adopted.

Mr. Wiley read the second recommendation, as follows:

Determination of water.—1.5 to 2.5 grams are dried to constant weight at the temperature of boiling water in a dish with flat bottom having a surface of at least 3 square inches.

The use of clean dry sand or asbestos with the butter is admissible, and is necessary if a dish with round bottom is employed.

Mr. Wiley suggested that the secretary be authorized to transform the 3 square inches into its equivalent in square centimeters, that the measure might be in conformity with the scientific standard. He said that the old method (page 209) differed from that now recommended; it required the use of clean dry sand and a temperature of 105°; the direction was to heat for two hours.

Mr. Myers moved that the suggestion be adopted. Carried.

Mr. Lupton asked whether the temperature was stated in the recommendation.

Mr. Wiley said that it was; the temperature was fixed at the boiling point of water, the standard temperature adopted by the association. Comparing Colorado with Louisiana, the difference in temperature would be very considerable, but the rate at which water went off from a substance depended generally upon the pressure and the temperature, and boiling water gave a constant condition everywhere, so that with that as a standard all worked under the same conditions although there was a difference in the actual temperature.

The recommendation, as amended, was adopted.

Mr. Wiley read the third recommendation, as follows:

Determination of fat.—The dry butter from the water determination is dissolved in the dish with absolute ether or with 76° benzine. The contents of the dish are then transferred to a weighed Gooch filter with the aid of a wash bottle filled with the solvent, and are washed till free from fat. The crucible and contents are heated at the temperature of boiling water till the weight is constant. The weight of the crucible and contents deducted from the weight of the dried butter gives the quantity of fat present.

Mr. Woods asked whether there was any way of knowing when the washing free from fat was accomplished.

Mr. Caldwell suggested that the solution be tested with nitrate of silver for chlorine.

Mr. Wiley said that would hardly do; in this case it was not chlorine

but fat that was to be washed out. Perhaps the best way was to take a drop on a platinum spatula, heat it, and see whether it gave off any fumes from the burning of organic matter. Each chemist could determine for himself whether all the fat was washed out; it was hardly worth while to encumber the method with that.

Mr. Cooke said that he thought some emphasis should be put on the word "absolute." Squibb's ether would not serve the purpose; the best ether made in this country would not answer for that requirement. Ether could be imported very cheaply; the imported ether could be brought here at from 63 to 65 cents a kilogram, which was very much cheaper than Squibb's ether, and would stand any of the tests he had tried.

Mr. Wiley said that the last sentence of the recommendation was evidently a clerical error. It said "the weight of the crucible and contents deducted from the weight of the dried butter gives the quantity of fat present." This was not so, for the weight of a crucible not there before had been introduced. The error could be corrected by substituting the statement that the weight of fat was calculated from the data obtained.

Mr. Myers suggested that either the secretary or the reporter should explain in a footnote the meaning of "76° benzine."

Mr. Huston said that it would be well to redistill the benzine; he had experienced considerable trouble with benzine, and he would bring up later the matter of its boiling points.

The president said that he had found in absolute ether something which had weight and was very explosive.

On motion, the recommendation was adopted.

Mr. Wiley said that the next recommendation contained a direct method; Mr. Cooke had said that there should be one. The fourth recommendation was as follows:

Substitute method for fat.—Water may be determined by drying the butter on asbestos or sand, and the fat extracted by anhydrous, alcohol-free ether in an extraction apparatus. The extract, after evaporation of the ether, is heated to constant weight at the temperature of boiling water and weighed.

Mr. Woods inquired whether any one present had tried the method in question; he had tried it without success.

The president said that he had tried the method and had reported the results, which were the same as by the other method.

Mr. Woods said that his results had sometimes been comparable, but sometimes they had not.

On motion, the recommendation was adopted.

Mr. Wiley read the fifth recommendation, as follows:

Determination of casein and ash.—The crucible containing the residue from the fat determination, consisting of casein and ash, is covered and heated gently at first, gradually raising the temperature to just below red heat. The cover may then be removed and the heat continued till the contents of the crucible are white. The loss in weight of the crucible and contents represents casein, and the residue in the cruci-

ble mineral matter. In this mineral matter, dissolved in water slightly acidulated, chlorine may be determined gravimetrically with silver nitrate.

The president asked if an alternate method was given; if the alternate were used for fat there would have to be one for the casein and ash.

Mr. Wiley said that no other method was given for casein and ash.

Mr. Myers moved to amend the recommendation by adding at the end thereof the words *or volumetrically*.

Mr. Wiley suggested the further addition of the words *using potassium chromate as an indicator*.

Mr. Myers accepted the suggestion.

The amendment was agreed to, and the recommendation of the reporter, as amended, was adopted.

Mr. Wiley said that it was often desired to determine only the salt in a butter. In that case the method given on page 209 would be found very easy of application, very accurate, and very quick. He had worked it hundreds of times, and knew it to be reliable. He moved that the method referred to be added as an alternate method for estimating salt. Carried.

Mr. Cooke moved that the Kjeldahl method be allowed as an alternate method for estimating the curd. Carried.

Mr. Myers said that it was frequently desirable to make other determinations, and that last year a series of elective determinations had been adopted and were incorporated in the printed method (pages 209-212); these methods seemed to be reliable. He moved their readoption as a whole. Carried.

Mr. Wiley said that the reporter had made no further recommendations. Beside butter there were other dairy products, but as to them no report was made by Mr. Jenkins; probably the association would do well to retain the methods of last year.

Mr. Voorhees said, referring to milk analysis, that he had made during the past year a long series of duplicate determinations, using the official method and the method of drying in a flat-bottomed dish. The results were very concordant; the average results of a very large number of determinations were almost identical with those obtained by the official method, and it was found that drying in flat-bottomed dishes without sand was very much more rapid and easier than the other way. He would like to see that method inserted either in place of the one now employed or as an amendment. He moved that the present method be amended as indicated.

Mr. Wiley said that the amendment could be easily made by inserting after the comma following the words "dry sand" (page 212) the words *or without sand*.

Mr. Voorhees said that the method did not mention a flat-bottomed dish; it was not necessary that the dish should be of platinum; nickel would answer.

Mr. Wiley said that the word "platinum" might be stricken out and

the words *or without sand* inserted after the comma following the words "dry sand."

Mr. Myers asked how Mr. Voorhees got rid of the thick covering of albumen which formed and dried.

Mr. Voorhees said that he did not try to get rid of it; he got the water out of it, it mattered not how.

Mr. Myers said that in West Virginia it would not get out.

Mr. Voorhees said that it did in New Jersey.

Mr. Wiley suggested that probably that was owing to the tendency everything had to get out of New Jersey.

Mr. Huston said he was not certain but that the method should prescribe a metallic dish of some kind; he had no experience upon the point, but thought that if platinum worked well something more should be known in regard to the matter before permitting the use of a dish made of porcelain, glass, or any other material less suitable than metal. It would be safe to say a metallic dish.

Mr. Woods said that he had repeatedly used a porcelain dish with sand, but never without it.

Mr. McDonnell said that he saw no reason why a glass dish should not be used; he had used a flat glass dish in drying butter and it worked very well; not having a flat platinum dish, he had taken the bottom of a flat beaker, and that answered every purpose.

Mr. Frear said that open capsules with flat bottoms served the purpose and dried very well.

Mr. Wiley said that he thought it perfectly safe to say simply *a flat dish*; then if a chemist found that one kind of a flat dish would not answer he might use another.

The amendment was agreed to, and on motion the method for determination of water, as amended, was adopted.

Mr. Voorhees, referring to the method for total nitrogeous matter, inquired whether it was necessary to evaporate the milk to dryness. The method said:

Evaporate to dryness in the Kjeldahl digestion flask a known weight (5 grams) of milk and proceed exactly as described for this method by the nitrogen reporter.

It had not occurred to him that it was necessary to evaporate to dryness if a good digestion could be had without that.

Mr. Wiley said that "dryness" here meant only smaller bulk; the evaporation was to be continued until the sample was thick.

Mr. Voorhees moved that the method be so amended as to prescribe that the Kjeldahl determination be made directly without evaporating to dryness. Seconded.

Mr. Wiley asked whether Mr. Voorhees had made determinations in that way, and had found them perfectly reliable.

Mr. Voorhees said that he had made three or four hundred such determinations, and they were perfectly satisfactory.

Mr. Van Slyke said that in the Geneva laboratory the plan of Mr. Voorhees had given most satisfactory results.

Mr. Cooke said that in his laboratory the sulphuric acid was put in without evaporating to dryness.

The motion was carried.

Mr. Wiley said that had he been a reporter on dairy products for the present year he should have recommended among the methods for fat estimation some of the commercial methods which had been brought into general use by Babcock, Patrick, and Parsons, and which had evidently proved successful. As it was, he had not kept track of the method during the past year, and therefore had nothing to offer further than to say that certainly the methods referred to might be included as alternate methods for the estimation of fat. He was inclined to believe that those methods were accurate, even for chemical purposes, and would like to know whether the members of the association had had experience with them.

Mr. Caldwell said that he had procured the apparatus and made a thorough trial of the commercial methods in his laboratory; he had found them all very nearly alike, and all very satisfactory methods for general use. He had not carried the experiment so far as to enable him to make a statement as to their comparative accuracy and convenience, but had selected Cochran's method as the one that seemed to him the most convenient of all.

Mr. Kedzie said that he had used the Patrick method and found that parallel samples determined by that method and by extraction with ether ran closely together, the differences being very trifling. The great difficulty with the Patrick method was that after using the tube a few times the rubber became leaky and the material spurted out on the fingers of the analyst, spoiling both the experiment and his temper; otherwise it answered very well.

Mr. Frear said that in his laboratory the Cochran and Short methods had been tested; the former had given satisfactory results; in using the latter he had occasionally found wider differences, and there was difficulty in securing complete saponification; otherwise it was all right. In the Cochran method there was no saponification to take place and very good results were obtained.

Mr. Farrington said that he read Mr. Caldwell's published work about a week before he was ready to publish his own report on the methods in question; he tried all the volumetric methods he could find in print. He thought that the methods of Babcock, Patrick, and Cochran could be relied upon for the determination of the fat as well as any of the gravimetric methods, and he moved that descriptions of the three methods named be printed in the proceedings of the association. Seconded.

Mr. Wiley said that the methods of Patrick, Parsons, and Short were published in last year's Bulletin on pages 163, 164, and 166, respectively. They were not given in the methods, because he had had no opportunity to test them. The other methods referred to had not

appeared at the time of publishing the bulletin. He thought Mr. Farrington's motion was a good one, and as the methods then just published were printed in the report of last year it might be well this year to describe the methods of Babcock, Patrick, and Cochran without adopting them. From what he had read he deemed these three the best of the methods proposed.

Mr. Cooke said that in his laboratory a method for milk analysis was used which had been published some time ago but had not yet come into general use; in fact, very few had ever heard of it. This was known as the "Beimling centrifugal milk test," and was really the application of the lactocrite to a simple and cheap hand machine. More than a thousand tests had been made with it in his laboratory, and he was so well pleased with it that probably within the next six months he should adopt it for use in analytical experiments requiring the utmost accuracy, in place of the Adams method, which he now employed.

Fifteen cubic centimeters of milk are put into a test bottle with a neck graduated to read per cent of fat direct, 3 cubic centimeters of half-and-half rectified amyl-alcohol and concentrated hydrochloric acid added and mixed with the milk by shaking, and the test bottle filled with oil of vitriol, the whole being mixed by shaking. The bottle is then whirled in the centrifuge for half a minute. The casein is entirely dissolved and the fat collects in the melted state, pure and perfectly free from all water, casein, etc., within the graduation of the neck, from which the per cent of fat may be directly and accurately read.

In regard to the accuracy of the method, he would say that one of the students, who was not a chemist, was set to work with the machine, and on the second day he made 24 determinations, 75 per cent of which came within one-tenth of 1 per cent of the results by the Adams method. Theoretically a machine should give more accurate results than the Adams method, or any other of the long methods, for it very largely reduced the personal equation. The whole operation on a single milk need not take more than three minutes, and twenty-five determinations an hour could be made by anyone of ordinary manipulative skill.

Mr. Penny said that he would like to ask whether the association desired to advertise a method already patented. The method of Cochran was manufactured and sold under a United States patent, and on that ground it did not seem exactly right to recommend it. He had had an opportunity of testing it when operated by the inventor, and comparing it with the gravimetric method. It operated very well, but was liable to occasional slips, for which no good reason could be assigned. He had also had an opportunity of comparing the method in the hands of a practical dairyman. Although it gave good results, he should regret to see it given a place in the proceedings of the association, for it was not a scientific method.

Mr. Myers said that he agreed with Mr. Penny in thinking that the association should not adopt patented inventions. When a man did

scientific work for the benefit of the public it ought to be brought forward. He objected very seriously to the incorporation of Cochran's method as a part of the system adopted. If chemists wished to use it, well and good.

The president said that the motion was simply to describe the method.

Mr. Myers said, that while the matter was one that each chemist would have to settle for himself, he very strongly disliked the tendency of investigators to patent methods. It was all right for a man to patent a piece of machinery if he could make anything out of it, but to patent a method of analysis was different. In his own laboratory, during the past year, some two thousand five hundred or three thousand analyses of milk had been made, comparing the methods of Short, Patrick, Adams, and the lactocrite. It was sometimes difficult to get accurately graduated tubes for either the Patrick or the Short method, but if proper care were taken and correct tubes selected these methods were to all intents and purposes equally accurate with the Adams method, or any of the older methods, and as the association was engaged in a work that would extend very largely to the experiment stations, the demands of workers in those stations should be considered in the adoption of methods. A man in an experiment station frequently needed the ability to make a great number of analyses in a short time; the same was true of persons who tested milk in the health departments of the cities; and where there was an accurate and thoroughly reliable mechanical method, like the one published by Babcock, or a quick method like Short's or Patrick's, he thought the association should use it. These methods were cheap, quick, and arrived at satisfactory results. He thought that the association would do well to adopt them, in a measure at least, in a qualified way, so that they should receive official recognition.

Mr. Caldwell said that he did not quite like the motion as it stood. He did not know why there should be no mention of the Parsons method, of which something could be said that he thought could not be said of the others. He considered it certainly superior to Patrick's method; in which the heating tube was, he believed, objectionable. He doubted whether it was worth while for the association to put its seal upon any of these methods at the present time, or to bring any one of them into prominence, all of them being on somewhat the same principle, without a more careful examination and testing; to do so would not be quite fair. The method mentioned by Mr. Cooke was entirely different in principle; but even that, he thought, ought to be tested, and it seemed to him that the association should proceed somewhat cautiously before recommending any one of the methods in question.

Mr. Farrington said that he had intended no unfairness in omitting mention of the Parsons method in his motion, which was simply to include in the proceedings of the association descriptions of new methods along with those already described.

The president said that, as he understood the motion, it was simply

that the methods referred to should be published in the bibliography as methods which had come out during the year, and without any recommendation.

Mr. Lupton said that it did not seem right to publish with the scientific methods of the association practical methods which were merely applications of principles, and all of which were, as he believed, patented. He would have the association remember that its proceedings were before the scientific world, and as for himself he wished to keep away from patents altogether, and doubted the propriety of publishing patented methods in the way proposed. Any chemist who wished to use or test these methods could get them.

Mr. Wiley asked whether any of the methods in question other than Cochran's had been patented.

Mr. Caldwell said that Cochran's method was the only one patented.

Mr. Lupton said that Short's method was used by dairymen, and he thought that something about it—probably the tubes—had been patented.

Mr. Wiley said that for his own part he should be opposed even to the publication in the bulletin of any method of analysis which was covered by a patent, as being outside the range of scientific investigation, and as the members of the association professed to be scientific men. There was, however, nothing in the laws of the United States prohibiting chemists from using any method they pleased, patented or unpatented, in their own laboratories. No patent law could prevent a chemist from estimating fat in any way he chose so long as he did it in the line of scientific research and not for gain, and similarly he might use any method for determining any substance. Nevertheless, the publication of a method was a recommendation, and he should much prefer to have the association omit Cochran's method and publish an account of the others in addition to those already inserted.

Mr. Caldwell said that he was in full sympathy with the opinion expressed by Mr. Wiley. When Cochran published his method in the *Journal of Analytical Chemistry* it was already patented, but the inventor did not say anything about that, and the speaker did not know it until after he had gone over the matter very carefully, which he did, being thus caught in a trap as it were.

Mr. Frear said that the method might be stated as a patented one. It was widely used in the Pennsylvania creameries, and the creamery men ought to have some statement as to its accuracy. So far as scientific investigation was concerned, he thought that Cochran had no idea of making gain from the method; but being used for gain as a commercial process in a large number of establishments, he had probably felt that it would be fair for him to receive a small share of the profits accruing to the creamery men from its use. It was not apparent that such an extension of patents to methods was foreign to scientific ideas; the method was not advocated for scientific, but for commercial pur-

poses. At the same time there was this effect, that those who used the method would have to buy the patented apparatus.

Mr. Van Slyke moved to amend the motion by striking out the Coehran and Patrick methods, already published, and inserting a report of the Babcock method, which had but recently appeared.

Mr. Myers moved, as a substitute for the original motion and the amendment, that the reporter on dairy products for the ensuing year be requested to take steps to test the accuracy of the new quick methods for milk analysis and report upon the same. Seconded.

Mr. Voorhees asked whether by the substitute it was proposed to include in the work of the reporter a comparison of the three methods in question with one another or with the gravimetric method. As he understood the substitute the reporter was to study and compare the results of these three methods.

Mr. Myers said that the substitute was so worded as to call simply for tests as to accuracy; the reporter was allowed to use any methods he should choose in testing that accuracy.

Mr. Burney said that inasmuch as certain of the methods under discussion had already been published, it seemed to him eminently proper that the others should appear in the same way, in order that those who cared to test them might have descriptions in convenient form.

Mr. Caldwell said that, as he understood, all the reporters were requested to give a summary of the literature upon their several subjects appearing during the year, and a notice of Babcock's method would therefore be inserted as a matter of bibliography. As to a description of the method, to which most of the members had access, he did not think it worth while to publish that.

Mr. Van Slyke said that an omission to publish a description of the Babcock method would seem unfair to its originator, who was well known to all members of the association as an accurate worker; everything published by him had been of value, and to pass over his method this year, having published methods something like it last year, would seem like ignoring it.

Mr. Wiley said that in Mr. Jenkins's report there was no bibliographical notice of any kind continuing the bibliography of the previous year. If proper, the association might request Mr. Jenkins to furnish a summary of the literature of dairy products from the time of the last report.

The substitute motion made by Mr. Myers was carried.

Mr. Stubbs moved that the reporter on dairy products be requested to furnish a complete bibliography of his subject for the past year. Carried; and the secretary was directed to make the request.

Mr. Penny rose to a point of order. He said that the motion made by Mr. Myers was in the nature of an amendment to substitute one motion for another which was then before the convention; that amendment having been voted upon, the original question was now in order; it had not yet been proposed. As he understood, the original motion

was that the methods which had been discussed should be reported on during the year.

The president said that Mr. Myers's motion had not been understood as an amendment, but as a substitute for the whole question.

Mr. Van Slyke said that a substitute was only one form of an amendment, to be treated like any other amendment.

Mr. Penny said that no member had power to make a substitute; only the association as a body could do that.

The president said that, according to his understanding, the substitute had been carried by the association.

Mr. Penny said that he did not think the association had voted upon the question at issue.

The president asked whether Mr. Penny was in favor of the motion.

Mr. Penny moved to amend the motion by adding the words, *excluding any method, apparatus, or device protected by a patent.*

Mr. Myers accepted the amendment, and the motion was seconded.

Mr. Caldwell said that he should be perfectly willing to exclude patented methods of testing, but he did not think that every piece of patented apparatus should be so excluded; he presumed that the apparatus referred to by Mr. Cooke was patented, and the present motion seemed to require that no method should be tested in which any piece of apparatus used was the subject of a patent.

Mr. Huston said that if care was not taken the power for whirling would be excluded; there were patents on most steam engines.

Mr. Lupton said that reference was now made to certain processes.

Mr. Stubbs said that the motion referred to chemical apparatus.

The president asked Mr. Penny to state the question in full.

Mr. Penny said that the motion was to amend by adding the words *excluding any apparatus or device protected by a patent; i. e.,* excluding from the motion any apparatus or device protected by a patent.

The motion, so amended, was lost.

Mr. Cooke said that the original motion was now in order.

The president said that, as he understood, the original motion had been adopted by the association, and Mr. Penny's motion, which had been lost, was simply a motion to amend the original motion; no further motion was necessary.

Mr. Voorhees asked whether any chemist present had been able to thoroughly extract the fat from the filter paper coils under the Adams method.

Mr. Cooke said that he saw no use in attempting to do so, and therefore never tried it; he took the paper just as it came and made a constant for it. He bought the paper in large quantities and tested individual strips of exactly the same size, cut by machinery. He tested a large number of such strips separately and then together, ascertained the limit of error for the different strips, put the milk directly on the filter paper just as it was received, and then subtracted the constant. The variation between one strip and another was not more than 0.005

of 1 per cent, calculated to 4 per cent milk, and he saw no reason for inserting the requirement that the paper be extracted before use. He moved to amend the method of Adams for determination of fat (page 212) by adding at the end of the first sentence thereof the words *or a constant determined for the paper*. Seconded.

Mr. Farrington said that some work which had been done by a German chemist tended to show that confidence could not be placed in a constant subtraction with ether. The results of his work had been published.

Mr. Wiley said that he had lately had considerable experience in weighing paper of uniform size, and judging by the weights obtained it would seem that paper must vary greatly in thickness; enormous differences might be found in the weight of strips alike in size. It was easy to weigh strips of paper, and he thought that if the amendment proposed should be to get a constant for paper of a given weight and then apply it to the strips, something very accurate would be obtained.

Mr. Cooke said that the variation on 4 per cent milk was very small; the total weight of extract was only about 0.09 of 1 per cent now, and it could vary but very little; if this extract varied one-tenth of its own weight from one paper to another, that would be only 0.01 per cent of fat.

Mr. Wiley said that Mr. Cooke's paper was evidently better than that ordinarily used; Mr. Cook was doubtless familiar with the work upon the subject which had been published in the Analyst.

Mr. Cooke said that he purchased the No. 598 paper.

Mr. Wiley said that the extract matter ought to be very evenly distributed in amount through the paper according to its weight.

Mr. Cooke said that was covered by the wording of the proposed amendment.

The amendment was agreed to.

Mr. Woods said that he had found it more convenient, and he thought more accurate, to run the milk directly from the pipette to the coil than to use the absorption process, and in the case of cream he had found it practically impossible to get a filter paper that would absorb anything like the required quantity. He moved that Mr. Wiley's method be adopted.

Mr. Wiley said that it was a method always used by himself on account of the difficulty stated by Mr. Woods.

The president asked Mr. Wiley to state the amendment.

Mr. Wiley said that it was to run the milk or cream upon the coil directly instead of absorbing it from a beaker, as was originally recommended by Adams, and as the method stood at present. The proposed method was a much better one; a weighed portion of milk could be used without danger of losing a drop if care was taken in running it upon the coil.

The amendment was agreed to; and on motion, the Adams method for determination of fat in milk analysis, as amended, was adopted.

Mr. Myers moved that the alternate method of Morse, Piggot, and Burton for the estimation of fat in milk (page 212) be stricken out. Carried.

Mr. Wiley moved that the alternate method of Babcock for estimating water and fat in milk (page 213) be continued. Seconded.

Mr. Huston said that he had a suggestion to make in regard to the manipulation in the Babcock method; if the air was forced up from the bottom of the tube instead of being drawn down through, the work was much more readily done.

The president asked whether Mr. Huston desired to offer an amendment.

Mr. Huston said that he was uncertain as to the phraseology, but understood that according to the method the air was forced downward.

Mr. Wiley said that the wording of the method did not so require; it only said that the air was to be drawn through.

Mr. Huston said that the method worked well when the air was drawn up, but did not work at all when the air was forced down.

The motion was carried.

Mr. Myers moved that the alternate method of Macfarlane for estimating water and fat (pages 213, 214) be continued. Seconded.

Mr. Caldwell asked whether there was anything particularly valuable in the Macfarlane method; he thought it did not differ much from Babcock's.

Mr. Wiley said that it was a more troublesome method than Babcock's.

Mr. Caldwell said that he saw no necessity for retaining the Macfarlane method, Babcock's being very similar and very good. He moved that the motion made by Mr. Myers be laid on the table. Carried.

Mr. Myers moved that the method for estimation of sugar in milk (pages 214, 215) be continued. Carried.

Mr. Wiley moved that the method of reduction of sugar by alkaline copper solution be added as an alternate method. Carried.

Mr. Myers moved that the method for estimation of ash in milk (page 215) be continued. Seconded.

Mr. Woods moved to amend the method by striking out the words "in muffle." He said that he saw no necessity for specifying in what the substance should be charred, it being specified that it was to be burned at a low red heat.

Mr. Wiley said that for the sake of safety he thought it better to incinerate in a muffle, but it could be done without.

Mr. Myers accepted the amendment, and the motion, as amended, was carried.

Mr. Myers moved that the methods for analyses of butter and milk, as amended, be adopted. Carried.

On motion, the convention adjourned until Friday morning at 9.30 o'clock.

SECOND DAY.

MORNING SESSION, FRIDAY.

The convention was called to order by the president at 9:30 o'clock.

The president appointed, as a committee to consider and report upon the recommendations contained in his opening address, Messrs. Myers, Wiley, and Kedzie.

Dr. Lupton presented the following report:

REPORT ON POTASH.

By N. T. LUPTON.

Since the last meeting of the Association, nothing whatever of interest on the determination of potash has been published, so far as my reading and observation have extended.

The methods recommended by this Association seem to give general satisfaction, and no suggestions of change or improvement have been made by those with whom your reporter has been in correspondence. Some points of interest in reference to the determination of moisture and the destruction of organic matter have been under investigation, but the results are not sufficiently advanced to be embodied in this report.

Samples, as usual, were prepared and sent to different chemists connected with experiment station work with a request to observe the following points:

(1) Determine moisture and potash strictly according to official methods and report the method or methods used.

(2) Make such suggestions of improvement in present methods as may be justified by experimental results, and report the results in detail.

The samples were obtained from manufacturers and dealers, and represent commercial goods, such as are in common use by farmers and planters. They were selected with reference to the difficulties usually met with in station work in the determination of potash, and as well suited to test the accuracy of our methods.

Four samples were sent, as follows:

(1) Commercial kainite.

(2) Cotton-seed meal.

(3) A commercial fertilizer, labeled, "Bone and potash."

(4) A commercial fertilizer, labeled "High grade vegetable fertilizer."

The manufacturer of "Bone and potash" says: "The formula is bone phosphate, rock, sulphuric acid, and muriate of potash. These are the only ingredients used." The manufacturer of the "High grade vegetable fertilizer" says: "The ingredients from which we derive phosphoric acid are mainly ground animal bone, but there is a small portion of high grade phosphate rock and also 38 per cent available phosphate and tankage. The sources of ammonia are the ground bone, tankage, dried blood, sulphate of ammonia, and a small portion of cotton-seed meal used as a drier. The source of potash is muriate of potash and the potash that may be in the small quantity of meal above mentioned."

The results reported from twelve agricultural experiment stations by seventeen chemists, making thirty-two determinations of potash in each sample, are presented in a tabular form as follows:

Station and chemist.	1. Kainite.		2. Cotton-seed meal.		3. Bone and pot-ash.		4. High grade vegetable fertilizer.	
	Mois- ture.	Potash.	Mois- ture.	Potash.	Mois- ture.	Potash.	Mois- ture.	Potash.
1. Connecticut: Messrs. Winton & Curtis.	9.80	{ 11.78 } { 11.84 }	6.25	{ 1.86 } { 1.89 }	18.40	{ 3.82 } { 3.93 }	9.53	{ 3.64 } { 3.71 }
2. Massachusetts: W. H. Beal.....	9.68	11.81 { 11.50 } { 11.53 }	6.91	1.87½ { 2.13 } { 2.16 }	18.69	3.87½ { 4.02 } { 4.01 }	9.87	3.67½ { 3.87 } { 3.88 }
3. New Jersey: E. B. Voorhees..... L. A. Voorhees..... C. G. Cathcart.....	8.69	11.51½ 12.00 12.00 12.04	7.69	2.14½ 1.50 1.66 1.63	17.96	4.01½ 3.94 3.90 4.01	9.32	3.87½ 3.88 3.89 3.90
4. Pennsylvania: W. S. Sweetser.....		12.01 { 11.70 } { 11.75 }		1.60 { 1.74 } { 1.71 } { 1.71 } { 2.04 } { 2.13 } { 2.17 }		3.95 { 4.21 } { 4.16 } { 4.18 } { 4.20 } { 4.18 }		3.89 { 3.91 } { 3.95 } { 3.97 } { 3.96 } { 4.19 } { 4.21 }
5. Maryland: H. J. Patterson.....	11.72½ 8.67	11.97½ 12.78		1.92 { 1.56 } { 2.11 }	17.82 18.46	4.18½ 4.33	8.90 9.61	4.03 { 4.21 } { 4.23 }
				1.83½				4.22 (3.28) (2.42)
6. Illinois: E. H. Farrington.....	9.80	12.33	8.15	1.31	20.37	4.28	11.40	4.01
7. Kentucky: H. E. Curtis.....	9.07	11.76	6.44	1.55	18.03	4.09	9.60	3.90
8. West Virginia: H. R. Baldwin, jr.....		11.63		1.71		4.10		3.91
9. North Carolina: J. R. Harris..... B. W. Kilgore.....	9.19	{ 11.44 } { 11.36 } { 11.44 } { 11.30 } { 11.16 } { 11.16 }	5.92	{ 1.47 } { 1.49 } { 1.67 } { 1.84 } { 1.87 } { 1.88 }	17.68	{ 4.15 } { 4.15 } { 4.23 } { 4.23 } { 4.23 } { 4.24 }	14.51	{ 4.66 } { 3.94 } { 3.92 } { 4.06 } { 4.05 } { 4.09 }
10. Louisiana: B. B. Ross.....	10.01	11.31 { 12.12 } { 12.02 }		1.67 a2.20 a2.21 b1.99 b2.05		4.20 17.87	4.00	4.02 { 3.83 } { 3.82 }
11. U. S. Department of Agri- culture: Aug. E. Knorr.....		12.06 { 6.92 } { 7.01 }		{ 1.85 } { 1.75 } { 1.69 } { 1.73 }	{ 19.29 } { 19.50 }	{ 3.92 } { 4.11 } { 4.27 } { 4.14 }	{ 9.98 } { 10.05 }	3.82½ { 3.97 } { 3.94 } { 4.19 } { 4.19 }
12. Alabama: I. T. Anderson..... P. L. Hutchinson.....	6.97 9.45 9.02	11.54 11.87 { 11.65 } { 11.68 } { 11.71 } { 11.71 }	6.51 5.81 6.59	1.75½ 1.94 { 2.00 } { 1.94 }	19.40 20.85 20.72	4.11 3.93 { 4.15 } { 4.17 }	10.02 9.29	4.07 3.91 { 3.91 } { 4.02 }
	9.23	11.72	6.20	1.96	20.78	4.08		3.96

Notes on the above received from those taking part in the work :

1. *Connecticut*.—The platinum solution gave theoretical results with pure salt. I should hardly expect any close agreement by different chemists on the sample of kainite; it seemed to me altogether too coarse. In reference to moisture, which was determined about a month after potash, the analyst says, under date of July 8: "As these samples have stood in partly filled bottles since June 28, when the potash determinations were made, I do not imagine that these water determinations represent accurately the quantity of water contained in the samples as received."

3. *New Jersey*.—With the exception of sample No. 2, the Lindo-Gladding method was used. The 1.50 per cent was secured by igniting the sample at low red heat and extracting potash with boiling water. In the other cases the alternate method of the Association was used in making the solution. Moisture in No. 2 was determined by drying in hydrogen. In all other cases the methods prescribed by the Association were used. We have nothing to suggest in the way of improvements on present methods.

4. *Pennsylvania*.—Determinations were made by three methods: (1) The water-soluble by the Lindo-Gladding method. (2) Water soluble by the alternate method. (3) Total soluble in nitric acid and a few drops of hydrochloric acid by the Lindo-Gladding method. The results on the total were very variable, and always too low when sulphuric acid was used to destroy the organic matter of Nos. 2 and 4, and the residue was burned to whiteness.

5. *Maryland*.—The Lindo-Gladding method was used. The low result in No. 4—3.28 potash—was evidently caused by the volatilization of some of the potash even with the utmost care. The incineration was done before boiling. The low result in No. 4—2.42 potash—is no doubt due to being held by the calcium sulphate which is formed in a hard mass. In this case the organic matter was destroyed with sulphuric acid.

7. *Kentucky*.—The official method, modified by Gladding, was used. In determining moisture, No. 1 was dried at 130° C. until the weight was constant. Nos. 2 and 4 were dried at 100° C. for five hours.

8. *West Virginia*.—The analyses were made by the method of Lindo as modified by Gladding. Nos. 1 and 2, averages of three determinations each. Nos. 3 and 4, averages of two determinations each.

9. *North Carolina*.—Washing with Gladding solution in dish gave better results than washing after transfer to crucible.

10. *Louisiana*.—In securing the results reported as *a* the sample of cotton-seed meal was saturated with sulphuric acid, heated for several hours until an ash, moderately gray in appearance, was obtained. It was then moistened with a few more drops of sulphuric acid, heated gently at first and then strongly over the blast lamps until all traces of carbon were destroyed and a transparent, vitreous mass was obtained. It was then dissolved in hot water, with the addition of a few drops of HCl and potash was determined in the usual manner. The results marked *b* were reached by simply igniting sample without previous moistening with sulphuric acid.

11. *U. S. Agricultural Department*.—The methods of analysis were strictly according to those adopted by the Official Association in the meeting of 1889.

The following table presents the results of each station reduced to the same percentage of moisture, viz: No. 1, 9 per cent; No. 2, 6.50 per cent; No. 3, 18.50 per cent; No. 4, 9.50 per cent. The table also presents the variation of each from the general averages:

Station.	Potash with 9 per cent. moisture.	Variation from average.	Potash with 6.50 per cent. moisture.	Variation from average.	Potash with 18.50 per cent. moisture.	Variation from average.	Potash with 9.50 per cent. moisture.	Variation from average.
1 Connecticut.....	11.91	-0.01	1.87	+0.08	3.85	-0.26	3.67 $\frac{1}{2}$	-0.29
2 Massachusetts.....	11.60	-0.32	2.15	+0.36	4.02	-0.09	3.89	-0.08
3 New Jersey.....	11.97	+0.05	1.62	-0.17	3.92	-0.19	3.88	-0.09
4 Pennsylvania.....	12.34	+0.42	1.92	+0.13	4.15	+0.04	4.00	+0.03
5 Maryland.....	12.73	+0.81	1.82	+0.03	4.33	+0.22	4.22	+0.25
6 Illinois.....	12.44	+0.52	1.33	-0.46	4.38	+0.27	4.10	+0.13
7 Kentucky.....	11.77	-0.15	1.55	-0.24	4.07	-0.04	3.90	-0.07
8 West Virginia.....	11.63	-0.29	1.71	-0.08	4.10	-0.01	3.91	-0.06
9 North Carolina.....	11.33	-0.59	1.66	-0.13	4.15	+0.04	4.25	+0.28
10 Louisiana.....	12.19	+0.27	2.10	+0.31	3.97	-0.14	3.80	-0.17
11 U. S. Dep. of Ag.....	11.29	-0.63	1.75	-0.04	4.16	+0.05	4.09	+0.12
12 Alabama.....	11.75	-0.17	1.95	+0.16	4.19	+0.08	3.96	-0.01
Average.....	11.92	.....	1.79	.....	4.11	.....	3.97	.....

These results, with two or three exceptions, are in close accord, and show that with proper care in manipulation and in the preparation of reagents employed, reliance can be placed on the results obtained by our methods.

The extension and rapidly increasing use of fertilizers has brought the skill of the agricultural chemist into greater demand than ever before, while the vast pecuniary interests involved have imposed additional obligations upon the analyst to spare no pains to secure the greatest possible accuracy. Of course, in the execution of commercial work, he should not be unmindful of his obligation to contribute as much as possible to the progress of pure science along whatever lines may be suggested by his daily work.

A continuance of the present methods of determining potash is recommended for the ensuing year. There are some slight changes in the directions given for carrying out the official methods which your reporter believes would be improvements.

(1) As recommended and adopted last year, it should be clearly stated that the precaution of charring organic substances, like cotton-seed meal, etc., and incineration with the addition of strong sulphuric acid must be observed with the Lindo-Gladding as well as with the alternate method.

(2) After boiling 10 grams of the fertilizer with 300 cubic centimeters of water for thirty minutes, as stated in the Lindo-Gladding method, add ammonium oxalate and ammonia before instead of after cooling. In other words, strike out "cool the solution."

(3) In the case of ordinary fertilizers there seems to be a waste of platinum solution by using 10 cubic centimeters containing 1 gram of platinum. From one-third to one-half this amount gives accurate results. One gram of the solution mentioned is theoretically capable of precipitating 0.4782 gram of potash, equivalent to 47.82 per cent.

(4) In the directions for carrying out the alternate method there is ambiguity in the statement about pulverizing. It reads as though the fertilizer is to be charred and ignited before pulverization.

The president introduced Hon. Edwin Willits, Assistant Secretary of Agriculture, who spoke as follows:

ADDRESS OF HON. EDWIN WILLITS.

Mr. President and gentlemen of the Association of Official Agricultural Chemists: I am gratified to see you this morning, having awaited with a good deal of interest the time for your assembling again in convention after testing some of the formulas which you elaborated last year and the year before. The very paper to which we have just

listened clearly indicates that you are greatly interested in your work and in the results you bring about by using, as you suppose, exactly the same methods. The personal factor enters into a chemical analysis as well as into all the affairs of life; the manipulation, the individuality, can be found there as well as elsewhere. Now, how can you average unless you compare these results, and how can what may be considered a false tendency be eliminated otherwise than by comparison?

The subject of chemistry is very deep and intricate; it is almost as old as the human race, and before it there is a great future. We have the consoling thought that in no line of investigation has all knowledge yet been attained. It does seem as though we are just on the eve of wonderful discoveries in your field and in others, and as I sit at my desk receiving the reports as they come in from all over this country, and mindful of the fact that nearly five hundred intelligent, scientific men are investigating the secrets of nature, my heart fairly bounds in contemplation of what may be the results of their work; and yet the consoling thought remains that though we may discover great things to-day or to-morrow, there is still a fountain of mystery, a wealth of intelligence, a wonderful source of law established by the Creator throughout all nature, and which the human mind may study for all ages and never compass. Great discoveries have been made heretofore, and looking back upon the acts of the great chemists you will sometimes wonder, What can we do? Can we find anything new? Can we accomplish anything? But it is certainly true that there are secrets yet to be divulged, and it may even be that one of these small keys that you yourselves are handling in the study of one of these seemingly small questions shall serve to unlock the depository of vast stores of knowledge, human and divine.

I believe in the experiment stations, and my hearty sympathy is with them; but my sympathy is most heartily with the chemists, because the experiment station was born in the chemical laboratory, of which it is an evolution; and probably so long as experiment stations shall exist the results obtained by all their other investigators shall be weighed and tested in the laboratories of their chemists. For there is something strange about this chemistry. Just as all the laws of nature are to be reduced to mathematics, so these investigations all center in the chemist's laboratory; and whatever of instruction you may get, whatever of information you may gather, and whatever new light may be thrown upon your work, I can most heartily understand and appreciate that your gain shall redound to the benefit of scientific investigators in all directions. The application of formulas will make results more certain. Of course mistakes have been made in the past and are being made now, and it is the correction of mistakes and errors that shall lead to more definite and final results.

I trust that your meeting this year may be successful, and that your work during the following year may be more nearly perfect and

complete; that your investigations and experiments may be conducted along more accurate lines, so that we may rely upon what you shall send to us as the proper analyses, not only of fertilizers, but of all the other matters which you are called upon to determine. I hope that you shall go back to your laboratories with renewed strength and with improved knowledge and information. I thank you for your kindness in asking me to show my sympathy—and I can do no more this morning—by appearing before you and encouraging you in your work.

The president stated that discussion upon the subject of potash was now in order.

Mr. Dancy said that there seemed to be a mistake in the phraseology of the Lindo-Gladding method (page 223), which had probably escaped the attention of the association, having been allowed to stand as it was for two or three years; he referred to the addition of the oxalate before the hydrate of ammonia. He would suggest that the ammonium hydrate be added before the ammonium oxalate; *i. e.*, that the solution be first made alkaline with ammonia, and the oxalate be added thereafter.

Mr. Gaines asked what difference that would make.

Mr. Dancy said that when the oxalate was added before the solution was made alkaline the lime present in combination with phosphoric acid was immediately precipitated. After the phosphate of lime was precipitated by the ammonia the oxalate was added to combine with whatever lime might be left in the form of sulphate. The oxalate, if added first, was used up in precipitating, as far as it went, from the general lime content. He saw no very good reason for adding the ammonia in slight excess, believing that a safe excess of ammonia would secure better precipitation.

Mr. Huston said, in regard to the last step in the operation, that of weighing the double salt of platinum, he had used a method which differed slightly from the manipulation prescribed, and which was suggested to the association some years ago, being that of filtering on an ordinary paper filter and dissolving the double salt with hot water after thorough washing. He had never failed to find on the filter papers, even in the Lindo method, a very appreciable residue of a material which was not double salt of platinum. He had therefore stopped using the Gooch crucible, and found it satisfactory to evaporate in a platinum dish. He thought it possible that some of the differences in results arose from something other than double salt which went into the crucible, but this was to be taken as a mere suggestion.

Mr. Frear said that in making a large number of duplicate determinations he had in one set left out the salt solution, and was curious to see what difference that would make in the ordinary run of commercial fertilizers. 0.0436 of 1 per cent was the mean difference, and the differences greater than 0.1 of 1 per cent were only two out of fifty; the

differences greater than 0.05 of 1 per cent where the salt was used and where it was not occurred in seventeen cases out of fifty. He had been able to work with equally good results without the salt solution in the case of ordinary fertilizers, and the method was a good deal more rapid. He simply desired to state the fact and to hear what there was to be said upon the other side.

Mr. Dancy said, again referring to the matter of the oxalate, that he wrote last year to Mr. Jenkins, who was then the reporter on potash, calling his attention to the order in which the two reagents were added. Mr. Jenkins had replied that the fact had theretofore escaped his notice, and that it was probably a mistake which had been overlooked from time to time; that he himself had never added the reagents in the order prescribed by the method as worded. The speaker would move that the ammonia be added first, and then the oxalate, and that the word "slight" be omitted.

Mr. Kedzie suggested that the words "cool the solution" be stricken out.

The president asked Mr. Dancy to state the proposed amendment specifically.

Mr. Dancy said that the amendment would so alter the method as to make it read as follows:

Boil 10 grams of the fertilizer with 300 cubic centimeters of water for thirty minutes. To the hot solution add ammonia in excess and then a little ammonium oxalate, thus precipitating all phosphate and sulphate of lime, oxide of iron, and alumina, etc.; make up to 500 cubic centimeters, etc.

the remainder of the paragraph being allowed to remain as at present.

Mr. Lupton asked whether it was intended to strike out the words "cool the solution."

Mr. Dancy said that his amendment included the striking out of those words before the direction to add the ammonia.

Mr. Kedzie said that as Mr. Dancy, being a commercial chemist, was not in a position to make the motion in question, he (Mr. Kedzie) would make it in his own behalf. He moved to strike out the words, "cool the solution; add a little oxalate of ammonia and then ammonia in slight excess," and to insert in the place thereof the words, "to the hot solution add ammonia in excess and then a little oxalate of ammonia."

Mr. McDonnell asked why it would not be well to strike out "cool the solution," and not to say, "to the hot solution add," etc. Then either the hot or the cool solution could be chosen.

Mr. Kedzie said that he thought better results were obtained by adding to the hot solution directly.

Mr. Voorhees said that he could see nothing to be gained by striking out the words "cool the solution." The chemists were obliged to cool the solution before filling to the mark, and it seemed to him better to make the additions to the cool solution. He asked what advantage would be gained by making the proposed change.

Mr. Dancy said that it had been his idea that the precipitation was more complete in the hot solution.

Mr. Myers said that if the solution were boiling it would, of course, drive off the ammonia; but the method only said "hot," and the precipitation would take place better in a moderately hot solution than in a cold one; it was of advantage to have the solution hot, but not boiling.

The amendment as proposed by Mr. Kedzie was carried.

The president said that he understood the amendment as covering the recommendation of the reporter (Mr. Lupton).

Mr. Lupton said that it did.

Mr. Robinson said that he should be glad to hear the experience of chemists in regard to the recommendation suggested last year, he believed by Mr. Jenkins, in regard to the use of one filtration instead of two (page 224). It was recommended by Mr. Jenkins that but one filtration be made; in other words, that the oxalic acid and ammonium oxalates be added immediately before the filtration, and that one filtration would suffice. His own experience was that this would very much facilitate the work, and without any sacrifice of accuracy.

Mr. Frear said that last year he had quoted the experience of the Maine station, where the method referred to was used exclusively. The chemists there said that in using this method they found no difference in their results over the theoretical result; that their results were concordant whether they used two filtrations or one, and that when both reagents were used at the same time the filtrations were much more rapid.

Mr. McDonnell said that the method in question was presented by Mr. Bartlett, of the Pennsylvania State College, some years ago, he having made a number of perfectly satisfactory experiments with it. Mr. Bartlett had since used it at the Maine station, where also it had given satisfaction. In the speaker's own experience it had proved better to filter all the precipitates together than to separate them.

Mr. Huston said that he was much surprised to hear Mr. Jenkins quoted as in favor of the method under discussion, for he remembered a conversation which took place about four years ago between Messrs. Richardson and Jenkins, in which the latter took the other side and objected very seriously to having the oxalate added before the barium hydrates were filtered off.

Mr. Frear asked whether Mr. Jenkins's objection was made as a result of experience or simply on theory.

Mr. Huston said that he did not know upon what Mr. Jenkins had founded his statement, but he had made a very positive one. He could not recollect just what Mr. Jenkins had said, as it was some years ago.

Mr. Van Slyke said that there seemed to be no definite data at hand in regard to the subject; he would therefore move that the reporter be requested to ask the analysts at the time of sending out the sam-

ples to make comparative determinations by one and two filtrations. This would give the association some definite data, and would place it in a position to act intelligently upon the question next year.

Mr. Cooke said that comparatively few chemists used the single filtration method at present, and it would be very difficult to get men to double or treble their work on the samples in testing a method not used in their laboratories; the Lindo-Gladding method was used in almost all the stations.

The motion was carried.

Mr. Myers said that the reporter had very properly called the attention of the association to an ambiguity or repetition to be found under the head of "Alternate method," at the foot of page 223 and top of page 224; the description was partially doubled. He moved that such ambiguity be removed by rearranging the first two sentences under the head of "Alternate method" so as to read as follows:

Pulverize the fertilizer (200 or 300 grams) in a mortar; take 10 grams. In case the potash is contained in organic compounds like tobacco stems, cotton-seed hulls, etc., it is to be saturated with strong sulphuric acid and ignited in a muffle to destroy organic matter.

Then proceed as prescribed—"Boil for ten minutes," etc.

Mr. Woods said that in some States the law prescribed the determination of potash soluble in water.

The president said that the association could not help that.

The motion was carried.

Mr. Huston said that he was compelled to work under such a law as Mr. Woods had referred to; the Indiana law said "potash soluble in water;" it did not say how long the treatment in water was to be continued, or whether the water was to be hot or cold. He had a certain class of goods which gave 0.7 in water and double that amount after treatment with sulphuric acid; he would like to have an expression as to the availability, at least, of that potash. Formerly he had ignited the goods, but a strict interpretation of the law would not allow that to be done, and as a result a good deal of fault was found with his work. He believed that potash which did not dissolve readily in water was none the less available for fertilizer purposes, but of course it could not be said to be soluble in water.

Mr. Myers said that his attention had recently been called by Mr. Jenkins to the fact that much of the chloride of platinum now on the market was adulterated with chloride of iron, and it was hard to get it purified. This was an unexpected and rather serious adulteration, and chemists should look out for it.

The reporter had called attention to some changes with reference to charring; he would like to hear the recommendation read.

Mr. Cooke said that if it was allowable he would move to take up all of Mr. Lupton's recommendations.

The president said that only one had been made, and that had been

passed upon; the matter referred to was probably in the nature of a suggestion.

Mr. Lupton said that in the alternate method the directions in regard to pulverizing, being ambiguous, had been changed. If permitted, he would read the slight changes proposed in his report. The first was as follows:

(1) As recommended and adopted last year, it should be clearly stated that the precaution of charring organic substances like cotton-seed meal, etc., and incineration, with the addition of strong sulphuric acid, must be observed with the Lindo-Gladding as well as with the alternate method.

That was adopted last year, but was not incorporated in the directions. Southern chemists had cotton-seed meal in all or nearly all of their complete fertilizers, and the charring was necessary. An interesting article on "Potash in Soil and Plants," by Berthelot and André, was published in *Comptes Rendus*, 105, pages 833 and 911, and an abstract of the same appeared in the *Journal of Analytical Chemistry*, Vol. II, 1888, pages 221 and 223. Presuming that nearly all the members of the association had seen this, he had not included it in his report. The article contained the following statement:

The potash in a plant may be divided into three parts:

- (1) That which is easily soluble in water.
- (2) That difficultly soluble in water and soluble in dilute acids.
- (3) That retained by the tissues of the plant against the solvent action of water and dilute acids.

This showed the importance of charring with a strong acid, such as sulphuric acid, in order to get out all the organic substance.

The president said that as he understood Mr. Lupton's recommendation it was that the clause directing the charring should be inserted also in the method of Lindo as modified by Gladding.

Mr. Lupton said that the president's understanding was correct; the recommendation was really adopted last year, but had not been inserted.

Mr. Kedzie asked what was to be done in States where the water-soluble was required by law.

The president said that in those States the law would have to be followed; the recommendation was applicable to States which had no such law.

Mr. McDonnell asked whether it would not be necessary for a manufacturer who sold his goods in two States, one of which had such a law and the other of which had not, to make different analyses and give different guaranties.

The president said that it would.

Mr. Lupton said that in the report of last year Mr. Jenkins had said (page 82, top):

It has been abundantly proved in past years that it is necessary to char such vegetable products as cotton-seed meal previous to extraction in order to accurately determine either the potash or the phosphoric acid, and I therefore feel justified in taking the higher figure, 1.90 per cent, as correct.

Mr. Battle said that he was in favor of the amendment indicated, but would like to inquire to what extent it could be known whether cotton-seed meal was present in the fertilizer. If the fertilizer was ammoniated entirely with cotton-seed meal there would be no trouble in distinguishing the fact, but a small amount of cotton-seed meal in the fertilizer could not be distinguished from the color; how then, in such a case, could it be known that it was necessary to char? The same trouble also existed in regard to tobacco stems. In North Carolina the potash in two or three brands was from tobacco stems, and in some cases it could not be told from the appearance how much or whether any stem was present, and it was therefore difficult to know whether to char or not.

Mr. Lupton said that the direction was to char in the case mentioned. It said:

In case the potash is contained in organic compounds like tobacco stems, etc.

Mr. Battle said that what he wished to know was how it could be determined whether or not the material was present in the fertilizer.

Mr. Huston said that he had fair success in detecting the material by noticing its behavior when wet; he thought that he could always tell when he had the soluble phosphoric acid leached out; he would not say that he could tell positively in that way, but it was very helpful in determining whether organic compounds were present.

The amendment was agreed to.

Mr. Lupton said that the next suggestion had been passed upon; the words "cool the solution" had been stricken out, and it had been directed that ammonia in excess and then oxalate of ammonia should be added to the hot solution. The next suggestion was as follows:

In the case of ordinary fertilizers, there seems to be a waste of platinum solution by using 10 cubic centimeters, containing 1 gram of platinum. From one-third to one-half this amount gives accurate results. One gram of the solution mentioned is theoretically capable of precipitating 0.4782 gram of potash, equivalent to 47.82 per cent.

In the alternate method (page 224) the amount of platinic chloride directed to be used was 10 grams, which was excessive, as accurate results could be obtained with less. He merely wished to call attention to the fact.

The president said that no amendment was proposed; it was only suggested that smaller quantities be used. He supposed that no more was required than was sufficient to precipitate the potash and other salts present.

Mr. Huston said that the platinum solutions in the two methods were not alike.

It was moved that the methods for determining potash, as amended, be adopted. Carried.

Mr. Caldwell presented the following report:

REPORT ON THE ANALYSIS OF CATTLE FOODS.

By G. C. CALDWELL.

This report is presented in three parts. In Part I an abstract is given of the journal literature on the subject from August, 1889, to August, 1890. Part II consists of the results of the analyses of the three samples sent out by the reporter, together with comments on the work, and supplementary investigations made by the analysts themselves. In Part III the reporter's recommendations for the ensuing year are offered.

PART I.

AN ABSTRACT OF THE JOURNAL LITERATURE ON THE SUBJECT.

THE HYDROSCOPIC WATER.

P. Baessler. Ueber die Bestimmung des Fettgehaltes der Mohnkuchen. Die Versuchstationen, XXXVI, 367.

The author finds, in some experiments with poppy-seed cake, that the determination of moisture gives lower results if the drying is done in air than if done in a current of hydrogen.

The Connecticut Agricultural Experiment Station. Apparatus for drying in hydrogen, by W. L. Winton. Annual report for 1889. Journal Analytical Chemistry, IV, 175.

— Drying oven. Annual report, 1889, 195. Journal of Analytical Chemistry, IV, 184.

Very large, to take in long pieces of fodder, as cornstalks.

— Hydrogen generator, by S. W. Johnson and T. B. Osborne. Annual report, 1889, 181. Journal Analytical Chemistry, IV, 169.

THE ASH.

W. Kwasnik. Das Calciumplumbat und seine Verwerthung zur Aschenbestimmung von vegetabilischen Substanzen, etc. Berichte der Deutschen Chemischen Gesellschaft, XXIII, 1890. Abstracts, 363.

A series of experiments has shown that the incineration is much sooner completed if one adds a weighed quantity of calcium plumbate. This salt gives a part of its oxygen to the combustible substance, and it is easily regenerated by taking up more oxygen from the atmosphere.

H. J. Patterson. Investigation on the determination of moisture in air-dry feeding stuffs. Annual Report Maryland Agricultural Experiment Station, 1889.

Over two thousand determinations made in the course of the study of the subject with reference to the questions—in what kind of a vessel to dry, how long to dry, at what temperature, in what medium, and what is the nature of the substance lost, and the general change in the process of drying. Slightly higher average results were obtained on drying in crucibles as compared with watch glasses. Generally the amount of loss increases with elevation of temperature and greater length of time of drying. No special and universal advantage was found in the use of any one medium over another in which to dry the substance. At the close of this report of progress the author states that "there can be no doubt that temperatures above 100° C. and heating for a longer time than six hours are to be used with great caution."

G. H. Failyer and J. T. Willard. Methods of analysis of feeding stuffs. The water. Annual Report Kansas Agricultural Experiment Station, 1889, 117.

Apparatus described to facilitate the desiccation in hydrogen. The authors conclude that complete drying is not assured in less than twenty to thirty hours. Figures are given in support of this conclusion.

THE ETHER EXTRACT.

P. Baessler. Ueber die Bestimmung des Fettgehaltes der Mohnkuchen. Die Versuchs-Stationen, XXXVI, 367.

The author refers to his having already shown that in the case of linseed cake the results of the determination of the ether extract are too low if the substance is first dried at 100° , unless in a current of hydrogen. He finds that the same is true with reference to poppy-seed cake. The result is also too low if the substance is dried in a vacuum over sulphuric acid.

He found that a small quantity of an apparently oily substance was carried over into the absorption apparatus by the current of hydrogen. But since the results of the ether extract determination on the substance dried in hydrogen are concordant, and higher than if made on substance dried in any other way, he concludes that this is not real fatty substance.

He proves that oxygen is absorbed when the substance is dried in air and carbon dioxide is given off.

If the substance is not heated above 90° in air it is almost fully dried in three hours, and a determination of ether extract on the substance so dried gives the same result as on the substance dried in hydrogen. It can not be heated higher than this without loss of fat, while linseed cake can be heated to 95° .

E. Wrampelmeyer. Die Bestimmung des Leinkuchenfettes. Die Versuchs-Stationen, XXXVI, 1889, 287.

Mentioning the papers by Baessler, Klopsch (Fresenius Zeitschrift für analytische Chemie, XXVII, 1888, 452), Märcher, Soxhlet, Stutzer, Bühring, and Siewert, and the want of full agreement between the results and conclusions of these authors, the author makes determinations covering some of the points in dispute, and proposes the following method:

For the extracting agent the ether need not be wholly dehydrated; shaking up the commercial article with calcium chloride is sufficient.

The air-dried substance is to be dried for one hour at the temperature of boiling water in a current of illuminating gas.

The extraction is to be made in a syphon apparatus, for three hours, and the rapidity of the boiling of the ether is to be so regulated that from one to one and one-half minutes elapses between the syphonings.

The residue left after distilling off the ether is to be dried for one hour at 95° to 98° in a Meyer drying oven.

R. S. Curtiss. Comparison of solvents for fat in feeding stuffs. Annual report of Connecticut Agricultural Experiment Station for 1889, 250.:

Ether, gasoline boiling at 45° to 50° , petroleum benzine boiling at 55° to 60° , petroleum benzine boiling at 75° to 80° , and chloroform were compared. The petroleum benzine was the most unsatisfactory of all; that and chloroform dissolve quite as much chlorophyll as ether does. No proof is found that the extract by benzine represents true fat more nearly than the ether extract does.

P. H. Irish. An apparatus for use in the determination of fat in plant substance. Bulletin No. 4, Oregon Agricultural Experiment Station, January, 1890.

For distilling from the extract and drying and cooling the fat in an atmosphere of hydrogen.

H. J. Patterson. The use of animal charcoal in the determination of fat in fodders. American Chemical Journal, XII, 1890, 261.

Puts in the percolation tube first animal charcoal, on that a plug of cotton, then the substance to be extracted, then another plug of cotton. The author proved that there was no loss of fat in the passage of the ether extract through the charcoal, the results being the same, in tests with pure fat, with and without the charcoal; on feeding stuffs the results were always higher without than with the charcoal, and with some kinds of fodder the differences were very large. The product obtained with

the charcoal is nearly pure fat; the charcoal takes up any water that may accompany the fat, and also ether-soluble acids from the plant substance, or formed from the ether as the result of the continuous distillation; the result of the ether extract determination is not so much affected by the age of the sample as without the use of charcoal.

G. C. Caldwell. An apparatus for the drying of substances in hydrogen. Bulletin XII, 1889, Cornell University Experiment Station.

THE FIBER.

G. Lange. Die Bestimmung der Cellulose. Zeitschrift für physiologische Chemie, XIV, 1889, 282.

By fusion of the substance with caustic alkali the author separates cellulose from Lignin; he seems to propose this as a method for the determination of fiber.

Cross and Bevan. The estimation of cellulose. Chemical News, LXI, 1890, 87.

G. H. Failyer and J. T. Willard. Methods of analysis of feeding stuffs: the crude fiber. Report of Kansas Agricultural Experiment Station, 1889, 119.

Connects the flask during the boiling with an inverted condenser, and also conducts in a blast of air which impinges on the surface of the liquid and keeps the foaming of the liquid under control.

G. Heinzelmann. Bestimmung der Holzfaser in Weizenkleie. Zeitschrift für angewandte Chemie, 1889, 557.

(See under Nitrogen-free extract.)

W. A. Withers. Some points on the determination of fiber in feeding stuffs. Journal of Analytical Chemistry, IV, 1890, 36.

The author gets more rapid filtration by treating the substance with NaOH first; the results that he obtains are concordant with those obtained by the usual method. He recommends covering the asbestos welt with glass wool for more rapid filtration, and conducting a current of air against the surface of the liquid while boiling with the reagents to prevent frothing. From his tests of the use of acid and alkaline solutions of different degrees of strength, and of treatment for different periods of time, he concludes that differences in the results follow such variations.

M. Honig. Zur Bestimmung der Rohfaser und der Stärke. Chemisches Centralblatt 1890, 2, 275.

The substance is heated to 210° with glycerine; the cooled mass is poured into alcohol (95 per cent), ether is added, the precipitate is filtered, and washed with a mixture of alcohol and ether (5 to 1), dried on a porous plate, treated with hot water, then hydrochloric acid is added, and the mixture is heated half an hour under a return flow condenser, and filtered; the cellulose is on the filter, the starch in the solution. Analyses are given, showing good results.

THE NITROGEN-FREE EXTRACT.

G. Heinzelmann. Bestimmung der Stärke in Weizenkleie. Zeitschrift für angewandte Chemie, 1889, 557.

The determination of fiber and starch in bran by the ordinary methods is inaccurate, the former being too low and the latter too high. He compared the determination of starch by treatment with .05 per cent lactic acid for two and a half hours under pressure of 3.5 atmospheres, and by treatment with malt extract; by the former method results were too high. The latter is the only reliable method.

IN GENERAL.

Fodder: Methods of analysis agreed upon at the International Chemical Congress at Paris. Chemisches Centralblatt, 1889, 2, 938.

Connecticut Agricultural Experiment Station. Grinding fodder; use of Otto gas engine. Annual Report 1889, 202.

PART II.

THE RESULTS OF THE ANALYTICAL WORK.

A copy of the official method was sent early in the fall of 1889 to each experiment station, with an invitation to coöperate in this work if the facilities were possessed for carrying out the method in all its details. Many of the stations accepted the invitation. Twenty reports have been received, including two distinct ones from the Pennsylvania Station.

The official method was followed apparently everywhere in all its essential details; in respect to such unimportant matters as the kind of filter used in the determination of the fiber, or the use of a blast of air to check the foaming in the same determination, or the mode of standardizing the acid and alkaline solutions in the determination of nitrogen, methods were followed in a few cases that differed from those officially prescribed. Only one important departure was noticed, the use of 5 per cent acid and alkali in the determination of the fiber in the laboratory of the Department of Agriculture.

Three samples were sent to each analyst, hay, wheat middlings, and linseed meal. The hay was first cut as fine as practicable in an ordinary hay cutter and a thoroughly mixed sample of this was ground in a steel mill, sifted through a sieve of the prescribed size of mesh; that which would not pass through was ground again and sifted, and this operation was repeated till the whole was reduced to the required degree of fineness. The whole of the powder thus obtained was then carefully mixed on a large sheet of paper. The middlings and linseed meal were ground, sifted, and mixed in the same manner.

The results of the analyses, calculated to dry substance by each analyst, are given in the following tables, and the extent of divergence in the results is exhibited in the same manner as it was in my report on the work of the preceding year. In making these calculations, in a very few instances the widest differences from the average were not included, when the divergence from the results obtained by all the other analysts was so great as to justify such omission. [More of these widely divergent results were omitted in the final preparation of this report for the press. This will explain the differences between the results of the calculations presented at the meeting, and those which are given here.—G. C. C.]

HAY.

State.	Analyst.	Moisture.	In the dry substance.						
			Pure ash.	Ether-extract.	Crude protein.	Crude fiber.	N-free extract.	Total nitrogen.	Alb. nitrogen.
California	M. E. Jaffa, G. E. Colby.	11.09	5.42	2.90	9.18	24.34	58.17	1.47	1.18
Colorado	D. O'Brine	7.39	*4.16	4.06	7.40	*16.35	*68.03	.....	.....
Connecticut.....	Connecticut Agricultural Experiment Station.	} 7.88	5.82	2.47	8.47	22.61	60.63	1.36	1.23
	Storrs Agricultural School, C. D. Woods, H. B. Gibson.								
Illinois	E. H. Farrington.....	10.00	5.78	2.07	8.46	22.02	61.67	1.35	1.18
Indiana	H. A. Huston	9.23	5.97	2.43	8.31	24.83	58.46	1.33	1.10
Kansas	G. H. Failyer, J. T. Willard.	9.47	5.47	2.28	8.80	23.67	59.78	1.41	1.14
Kentucky	A. M. Peters.....	9.33	5.85	2.06	8.63	24.18	59.28	1.38	1.17
Maryland	H. J. Patterson	10.60	5.07	3.47	.....	23.75	.....	.....	.....
Missouri	P. Schweitzer	} 9.67	6.36	1.88	8.85	23.22	*56.67	1.42	.....
	B. v. Herff								
New Jersey	L. A. Voorhees.....	8.50	5.79	2.52	8.88	22.33	60.48	1.42	1.30

* Not included in the above averages, and comparisons of results.

† We are informed by the author that a recalculation shows those figures to be in error; that the true number is 59.67.

HAY—Continued.

State.	Analyst.	Mois- ture.	In the dry substance.						Alb. nitro- gen.
			Pure ash.	Ether ex- tract.	Crude pro- tein.	Crude fiber.	N-free ex- tract.	Total nitro- gen.	
New York	Cornell University, W. P. Cutter.	8.53	5.48	2.26	8.68	24.56	59.22	1.39	.....
Colorado	Cornell University, H. Snyder.	8.33	5.45	2.82	8.56	23.89	59.28	1.37	.....
North Carolina....	B. W. Kilgore.....	8.91	6.29	3.21	7.81	26.90	55.79	1.25	1.16
Pennsylvania	W. Frear, A. Fries, H. B. McDonnell.	9.12	5.83	*5.60	8.94	24.89	55.54	1.43	1.09
Texas	H. B. McDonnell	8.39	5.67	4.08	8.81	23.63	57.81	1.41	1.18
U. S. Department of Agriculture.	D. Adriance.....	*15.26	6.82	4.26	*12.18	*29.33	*47.41	*1.95	.....
Virginia	Aug. E. Knorr, T. C. Trescot.	8.57	6.09	2.15	8.94	†18.76	†67.16	1.43	.....
West Virginia....	W. Bowman	8.77	5.50	3.00	8.66	23.42	59.41	1.38	1.24
	H. R. Baldwin	7.11	6.25	2.49	8.30	20.49	62.47	1.38	1.14
Averages		9.40	5.94	2.73	8.58	23.61	58.60	1.38	1.17
Difference between highest and lowest per cent			1.75	2.20	1.78	6.41	6.93	.....	.....
This difference expressed in per cent of average			29.5	80.6	20.7	27.2	11.8	.....	.....
Widest difference from average			.88	1.35	1.18	3.29	3.87	.....	.....
This difference expressed in per cent of average			14.8	49.5	13.8	13.9	6.6	.....	.....

WHEAT MIDLINGS.

California.....	M. E. Jaffa, G. E. Colby.	13.60	1.02	1.99	13.59	0.86	82.54	2.18	1.84
Colorado	D. O'Brine	9.91	1.22	2.55	*9.62	*2.90	83.71	.....	.....
Connecticut.....	Connecticut Agricultural Experiment Station.	11.06	0.96	1.91	13.00	1.36	82.77	2.07	2.03
	Storrs Agricultural School, C. D. Woods, H. B. Gibson.	11.65	0.94	1.73	13.13	0.62	83.58	2.10	1.96
Illinois	E. H. Farrington	12.40	0.80	1.55	13.13	0.96	.....	2.10	1.70
Indiana	H. A. Huston	9.63	1.18	2.67	12.16	0.70	83.56	1.95	1.94
Kansas	G. H. Failyer, J. T. Willard.	11.75	0.84	1.78	12.61	0.79	83.29	2.02	1.62
							83.98		
Kentucky.....	A. M. Peters	12.25	0.92	1.82	12.81	0.62	83.83	2.05	1.81
Maryland	H. J. Patterson	11.95	0.91	1.93	.....	0.98	.....	.....	.....
Missouri	P. Schweitzer	13.27	1.14	1.73	13.25	0.64	83.24	2.12	.....
	B. v. Herff								
New Jersey	L. A. Voorhees	10.70	0.96	1.87	12.98	0.69	83.50	2.08	2.05
New York	Cornell University, W. P. Cutter.	9.77	*2.55	1.74	12.96	*2.51	*80.24	2.07	.....
	Cornell University, H. Snyder.	9.84	0.84	1.76	12.70	0.86	84.04	2.03	.....
North Carolina...	B. W. Kilgore	11.51	1.18	1.97	11.68	1.17	84.00	1.87	1.74
Pennsylvania....	W. Frear, A. Fries, H. B. McDonnell.	.....	1.14	2.01	13.37	0.73	82.75	2.14	1.95
	H. B. McDonnell	10.77	1.01	2.11	12.06	0.69	84.13	1.93	1.89
Texas	D. Adriance	14.57	1.01	2.10	12.12	0.89	83.89	1.94	.....
U. S. Department of Agriculture.	Aug. E. Knorr, T. C. Trescot.	11.70	0.95	2.15	13.09	0.63	85.12	2.10	.....
Virginia	W. Bowman	11.52	1.03	2.25	12.33	0.67	83.72	1.99	1.99
W. Virginia.....	H. R. Baldwin	8.09	0.90	2.74	.....	0.75	.....	.....	1.77
Averages		11.32	0.99	2.02	12.79	0.71	83.63	2.04	1.92
Difference between highest and lowest			0.42	1.19	1.91	0.74	2.58	.....	.....
This difference expressed in per cent of average			42.4	58.9	14.9	104.2	3.08	.....	.....
Widest difference from average			0.23	0.72	1.11	0.65	1.49	.....	.....
This difference expressed in per cent of average			23.2	35.6	8.7	91.6	1.8	.....	.....

* Not included in the above averages and comparisons of results.

† Not included in the above averages and comparisons of results, 5 per cent acid and alkali having been used in the treatment for the fiber.

LINSEED MEAL.

State.	Analyst.	Moisture.	In the dry substance.						
			Pure ash.	Ether extract.	Crude protein.	Crude fiber.	N-free extract.	Total nitrogen.	Alb. nitrogen.
California	M. E. Jaffa, G. E. Colby.	10.99	5.66	9.91	42.62	8.40	33.42	6.82	6.45
Colorado	D. O'Brine	8.04	5.40	*11.15	*28.60	8.82	*46.03	.....	.....
Connecticut	Connecticut Agricultural Experiment Station.	9.02	6.10	9.71	41.08	8.08	35.03	6.57	6.20
	Storrs Agricultural School, C. D. Woods, H. B. Gibson.	9.23	5.87	9.48	41.63	7.49	35.53	6.66	6.37
Illinois	E. H. Farrington	9.88	6.30	9.33	41.40	7.67	35.30	6.62	5.70
Indiana	H. A. Huston	7.81	6.11	9.90	39.45	7.64	36.90	6.35	6.30
Kansas	G. H. Failyer, J. T. Wil- lard.	9.03	5.74	9.62	40.50	7.52	36.62	6.48	6.01
Kentucky	A. M. Peters	9.57	6.00	8.86	40.06	7.59	34.49	6.41	5.93
Maryland	H. J. Patterson	10.00	5.57	9.99	.....	7.57	.....	.....	.....
Missouri	P. Schweitzer	10.25	6.43	9.24	41.06	7.43	35.84	6.57	.....
	B. v. Herff .....	.....	.....	.....	.....	.....	.....	.....	.....
New Jersey	L. A. Voorhees	8.49	6.01	9.59	40.64	7.21	36.55	6.50	6.32
New York	Cornell University, W. P. Cutter.	6.85	5.17	9.46	38.66	9.01	38.70	6.18	.....
	Cornell University, H. Snyder.	8.15	5.43	9.90	41.18	7.20	36.29	6.55	.....
North Carolina	B. W. Kilgore	9.65	6.18	9.98	37.12	7.98	38.74	5.94	5.51
Pennsylvania	W. Frear, A. Fries, H. B. McDonnell.	.....	6.02	9.58	39.06	7.81	37.53	6.25	6.26
	H. B. McDonnell	8.70	5.61	9.63	40.69	7.80	36.27	6.51	5.02
Texas	D. Adriance	12.79	6.36	9.86	41.18	9.61	32.99	6.59	.....
U. S. Department of Agriculture.	Aug. E. Knorr, T. C. Prescott.	8.91	5.92	9.29	41.25	7.37	41.91	6.60	.....
Virginia	W. Bowman	* 8.95	6.06	9.45	40.34	7.65	36.50	6.45	6.28
West Virginia	H. R. Baldwin .....	.....	.....	9.02	*55.97	*5.82	43.54	.....	5.11
Averages .....	.....	9.25	5.89	9.57	40.77	7.41	36.82	6.48	5.95
Difference between highest and lowest .....	.....	.....	1.26	1.12	5.50	2.41	8.92	.....	.....
This difference expressed in per cent of average .....	.....	.....	21.4	11.7	13.5	32.5	24.2	.....	.....
Widest difference from average .....	.....	.....	0.72	0.71	3.65	2.20	5.09	.....	.....
This difference expressed in per cent of average .....	.....	.....	12.1	7.4	9.0	29.7	13.8	.....	.....

* Not included in the above averages and comparisons of results.

COMMENTS AND SUPPLEMENTARY INVESTIGATIONS BY THE SEVERAL ANALYSTS.

THE HYGROSCOPIC WATER.

Colorado.—A longer time was required to get a constant weight drying in hydrogen than in the usual way, from twenty to thirty minutes. On heating longer than three hours and twenty minutes, the sample increased in weight in every experiment.

Connecticut (Storrs School).—"The loss in weight at the end of five hours was considered to represent the moisture content of the samples. In the case of the middlings and linseed meal there was practically no loss in weight after five hours, but the hay continued to lose, and it was not dried to constant weight. Have always noticed this peculiarity in the drying of coarse fodders."

Missouri.—From the results of over sixty determinations of moisture the following averages are taken and conclusions drawn. The hydrogen and illuminating gas were passed through potassium permanganate and then dried before coming in contact with the substance.

Sample.	In hydrogen.			In illuminating gas.		
	1 hour.	2 to 3 hours.	Over 3 hours.	1 hour.	2 to 3 hours.	Over 3 hours.
Hay	9.50	9.67	9.79	9.77	9.63	9.73
Middlings	13.34	13.27	13.30	13.16	13.21	13.21
Linseed meal	10.27	10.25	10.26	9.94	9.97	10.02

"With air-dry fodder, drying for one to two hours is quite sufficient when dry hydrogen gas is used; a longer heating is disadvantageous to subsequent fat extraction. Where the drying is done in air, partial oxidation with consequent apparent decrease of water occurs, as seen in the following figures, obtained by drying the substance in air for four hours; the greatest apparent diminution being in middlings and linseed meal, probably because the fat is more readily oxidized than other constituents are."

	Per cent.
Hay	9.08
Middlings	12.17
Linseed meal	9.23

Some desiccator tests were made with one series of samples, giving a slight but continuous loss of moisture with increasing length of exposure in the desiccator, as shown by the following figures. The substance was first dried for two hours at the temperature of boiling water; the per cent of moisture thus found is given in the first column.

Sample.	Drying 2 hours.	Then in desiccator—			
		10 min- utes.	20 min- utes.	30 min- utes.	2 hours.
In hydrogen:					
Hay	9.61	9.56	9.54	9.51	9.38
Middlings	13.14	13.10	13.07	13.05	12.90
Linseed meal	10.00	9.98	9.96	9.95	9.92
In illuminating gas:					
Hay	9.42	.....	9.41	.....	9.35
Middlings	13.10	.....	.....	13.05	.....
Linseed meal	9.86	9.85	.....	9.79	.....

Texas.—The hay was stated to be sour like ensilage when received. The very large per cent of moisture reported indicates that all the samples had been unusually exposed.

U. S. Department of Agriculture.—The results reported are the highest figures obtained by drying to constant weight, requiring twelve to sixteen hours. For practical purposes the analyst of the samples, Mr. Knorr, recommends seven hours as sufficient, the moisture being driven off to within 0.04 to 0.06 per cent and duplicates agreeing very closely.

THE ASH.

Kentucky.—The ash of the middlings and the linseed meal contained only traces of CO_2 . In the ash of the hay the CO_2 was estimated by loss of weight of the apparatus.

Missouri.—The ash of the middlings and of the linseed meal contained no CO_2 ; that of the hay 0.38 per cent.

U. S. Department of Agriculture.—The determinations were made according to the old method, incinerating to whiteness at the lowest possible temperature.

THE ETHER EXTRACT.

Kansas.—An all-glass syphoning extractor was used.

Kentucky.—Besides using the official method, trials were made on the substance dried in a watch glass in the air, and in every case the results were lower, being 8.46 per cent for the hay, 10.47 for the middlings, and 8.26 for the linseed meal. With one sample of linseed meal 8.86 per cent of extract was obtained; it was suspected that the supply of hydrogen gave out during the desiccation, and that the result would prove to be too low. On bringing all the results together, obtained by the different analysts, this proved to be the case, and it was therefore left out by the reporter.

The determination of the ether extract by loss of weight of the extraction tube (Caldwell's) gave in all cases a lower result—1.98 for the hay, 1.13 for the middlings, and 8.32 for the linseed meal.

Maryland.—The results on ether extract purified by animal charcoal were, on hay 3.07, middlings 1.71, and linseed meal 8.91 per cent.

Illinois.—The ether extract was not dried in hydrogen.

Missouri.—From the results of over one hundred experiments the following averages are given and conclusions drawn. The anhydrous ether used was "made in the laboratory from stronger ether freed from alcohol by washing; requires much precaution to keep it from absorbing moisture; a chloride of calcium tube was attached to the upper end of the condenser."

The extraction tubes with the extracted substance were dried in hydrogen and weighed, giving the ether extract by loss of weight as well as by direct weighing of the extract.

In the following table the effect of different times of extraction is shown, the time being given in hours:

Name of substance.	Anhydrous ether, substance dried in—				Stronger ether, substance dried in—				Petroleum ether, substance dried in—			
	Hydrogen.		Illuminating gas.		Hydrogen.		Illuminating gas.		Hydrogen.		Illuminating gas.	
	Time of extract.	Per cent of extract.	Time of extract.	Per cent of extract.	Time of extract.	Per cent of extract.	Time of extract.	Per cent of extract.	Time of extract.	Per cent of extract.	Time of extract.	Per cent of extract.
Hay	13	1.70	13	1.69	8	2.09	8	2.98	12	1.28	12	1.32
Do	60	1.89	60	1.88	63	5.84	54	5.42	60	1.31	60	1.35
Middlings	13	1.50	13	1.48	8	1.62	8	1.55	12	1.30	12	1.14
Do	60	1.55	60	1.53	63	2.10	63	2.05	60	1.31	60	1.32
Linseed meal	13	8.29	13	8.32	8	8.62	8	8.70	12	7.58	12	8.01
Do	60	8.38	60	8.41	54	9.45	63	9.60	60	8.00	60	8.03

The difference between the two series with anhydrous sulphuric ether and with petroleum ether ranges from 0.24 to 0.48 per cent, and is always in favor of the sulphuric ether.

It is plain that anhydrous ether is the best medium for extracting fat, and that the extraction is complete at the end of thirteen or, say, fifteen hours; a longer treatment removes only small portions of resinous or waxy matters, but no fat. Petroleum ether is not so effective, requiring in the first place a longer time for action, and leaving behind, in the second place, a portion of the fat, or of the resin and wax heretofore counted as fat. For that reason I consider the first set of figures to give the correct values for the two solvents, and reject the figures obtained in the hydrogen and gas-dried material with stronger ether. Successive extractions made with the latter seem to increase the water in the substance and wash out sugar, as proven by test. Compensation of the errors might be effected by reducing the time for extraction from eight to six hours or drying the material as well as the extracted matter in air instead of hydrogen or gas. A determination made in this way gave the following results:

Per cent.	Per cent.
1. 2.29....duplicate....	2.26
2. 1.49....duplicate....	1.49
3. 8.54....duplicate....	8.75

When the tubes containing the extracted substance were dried, with their contents, in hydrogen, or in illuminating gas, according as they were dried in one or the other at first, this determination of the extract by loss of weight gave results higher by

from 0.04 up to 0.34 per cent, this difference being less in the case of the extraction with petroleum ether than with either of the other extracting agents. A similar result was obtained in the laboratory at Cornell University. It is difficult to explain this divergence, and I do not know that we are in a position to decide which result is to be taken as the correct one, the direct or the indirect one.

In the above table the results are given only for the two extremes of time—the shortest time, and the sum of all the periods of extraction. With the anhydrous ether there were three successive extractions of the same portion of substance, the first for thirteen hours, the second for twenty-five hours, and the third for twenty hours, making the total about sixty hours, for which the second result was given. The quantities extracted in the second and third operations were very small for both anhydrous sulphuric ether and petroleum ether, usually less than 0.1 per cent, and in one case only, with linseed meal running up to 0.18 per cent; but the difference between this behavior and that with the Squibb's stronger ether was remarkable, as shown by the figures which are given below:

3.—*Squibb's stronger ether—first extraction for ten hours, and each subsequent extraction for seven hours.*

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	3.09	0.52	0.19	0.48	1.02	0.54
2	1.62	0.05	0.10	0.06	0.14	0.13
3	8.62	0.19	0.10	0.19	0.05	0.30
4	2.98	0.53	0.24	0.47	0.34	0.86
5	1.55	0.00	0.15	0.05	0.12	0.08
6	8.70	0.23	0.17	0.05	0.23	0.22

U. S. Department of Agriculture.—Seven hours was found sufficient for the complete extraction, and “less would not probably be safe in all cases.”

THE PETROLEUM ETHER EXTRACT.

California.—With these samples, as in many other cases in their experience, it has given poor results. The extract amounted to less than half of that resulting from the treatment with ordinary ether. “Somehow the petroleum product obstinately refuses to penetrate a number of materials as thoroughly as a solvent does that is more or less soluble in water.”

Connecticut (New Haven).—“Have made previous comparisons of the solvent effect of various petroleum benzine fractions with ether and chloroform, and have found that the benzine in all cases extracts less than ether, but most certainly extracts chlorophyll as completely as ether. We considered therefore that it has no advantages, and some disadvantages.”

Kentucky.—“The manipulation was not as satisfactory as with ordinary ether on account of the petroleum ether containing products varying several degrees in boiling point, although it had been refractionated between 40° and 45°.”

Reports on petroleum ether extract.

	Hay.	Middlings.	Linseed meal.
Indiana	2.19	2.42	9.68
Kentucky	2.05	1.86	9.18
New York	1.63	1.66	9.05
Pennsylvania (McDonnell)	{ 1.82	1.55	9.21
Virginia	{ 1.87	1.89	9.55
	2.30	2.06	9.84

THE FIBER.

Connecticut (New Haven).—Did not use blast, but were not troubled with foaming of the liquid. Were more troubled with bumping in the treatment with alkali on account of the presence of the asbestos and glass wool of the filter.

Connecticut (Storr's School).—Were quite unsuccessful in the use of the asbestos and glass-wool filter; used linen with more concordant results, and much more uniformly rapid filtration, in no case requiring more than four minutes, while the time required for the filtration with the asbestos and glass-wool filter ranged from four minutes to six hours for the acid extract, and three to thirty minutes for the alkaline extract. With the linen filter ten minutes is sufficient time in which to make the filtration from the acid solution, wash the residue, transfer to the flask, and bring the alkali to boiling. The filtration from the alkaline extract is made on linen, and then a transfer is made to a Gooch crucible, so as to insure perfect washing. On two hundred determinations of fiber in that laboratory the time necessary for completing duplicate analyses, from boiling of acid to putting washed crude fiber in the drying oven, varied from one and one-half to one and three-fourths hours.

One trial was made with linseed meal, using alkali first and the asbestos filter, but the filter became completely choked.

Indiana.—Used linen filters for both acid and alkali filtrations.

Kentucky.—The soda solution used contained a small quantity of carbonate.

Illinois.—The attempt to use the alkali first was a failure, on account of slow filtration.

Missouri.—Some small variations were made in the treatment of the substance in the twenty-four determinations of fiber. In one series the residue from the extraction of the substance dried in hydrogen or in illuminating gas with anhydrous ether was treated with a sodium hydrate free from carbonate; in another series it was the residues from the treatment with Squibb's stronger ether, using a sodium hydrate not free from carbonate; and in a third series the substance was originally dried in air, otherwise treated as was the second.

The results with the second series were slightly higher and those with the third and slightly lower than with the first, but the difference was in no case greater than 0.78 per cent on the hay, was not over 0.2 per cent with the middlings, and but a trifle over 0.3 per cent on the linseed meal, insignificant compared with the variations on the same sample by different analysts.

North Carolina.—The trial of the plan of treating first with alkali and then with acid gave no advantage, except with the middlings, when it was more satisfactory.

Pennsylvania.—The results on fiber were obtained by two analysts, each getting a number of closely agreeing duplicates, with manipulation essentially the same, but differing on the hay by 0.8 per cent; this is quoted by Mr. Frear as illustrating the difficulty of the determination.

Mr. McDonnell used for his filter a perforated platinum cone in an ordinary funnel covered with an asbestos felt.

Texas.—The boiling was done in an open Erlenmeyer flask.

United States Department of Agriculture.—It was found next to impossible to filter the solutions with the acid and alkali of official strength. The opinion is given that "so weak an acid will not saccharify all the starch of so farinaceous a substance as the middling in half an hour. Therefore 5 per cent solutions were used, as formerly in the laboratory of the Department, and no further trouble was encountered."

A comparison of the percentage statements of the divergence of results at the close of each table with the corresponding statements of last year does not give evidence of any satisfactory progress toward closer agreement between the results obtained by different analysts. Last year I expressed the opinion that the difference between the lowest and highest result on any one constituent should not exceed 15 per cent of the average, and that 10 per cent should be the limit for the widest variation above or below the average.

In making these calculations last year no results were rejected; this year I did not include those very small in number, which differed so widely from all the others of the same series that they could reasonably be regarded as incorrect; but notwithstanding this advantage given to the results of this year, the showing for them is better only in a few instances, and is worse in the majority of them, only those series being compared for which the calculations have been made in both years.

Last year some deviations from the official method were considered as possibly of sufficient importance to account for such serious discrepancies in the results; therefore strict adherence to the official method was specially requested by the reporter in the work of this year. Nevertheless the extreme variations are still just as wide or wider.

PART III.

This serious and persistent want of agreement between results may be due to three causes: First, incomplete mixing of the mass of ground material before taking out the several samples; second, imperfections of the methods of analysis; third, inexperience or carelessness in the execution of the work.

As to the first cause suggested, incomplete mixing, if it be this, then we may well doubt the sufficiency of any sampling of a large mass of fodder, if no dependence can be placed on uniformity of composition of a mass of fine powder treated as these samples were prepared. Further, it is easy to select several series of results on one constituent that agree fairly well while there are wide discrepancies in the results obtained by the same analysts on some other constituent; it would be reasonable to suppose that any want of uniformity in the samples would affect all the constituents.

In order to test this important matter your reporter would recommend that a portion of the ground substance, prepared for the analysis in the same manner as this year, be subjected to further mixing in a slowly revolving rectangular box not more than one-third or one-half filled with the powder, the revolution being continued for several hours, and that samples of this portion be sent out as well as of the other.

As regards the second possible cause, imperfections in the methods of analysis, it is reasonable to suppose that every sample would be affected alike when the same methods manipulated in the same way are strictly followed by all analysts. Little satisfaction appears to be gained in attributing the discrepancies to this cause.

As regards the third reason suggested, some of the widest variations from the average are reported by those whose experience and carefulness can not be reasonably questioned; and it is altogether too much to ask of the "personal equation" that it shall bear the blame for such wide discrepancies as may be found scattered through these tables. To your reporter it appears that there is nothing else to do than to await further developments from continued work along these lines.

The late date at which many of the reports were sent in, accompanied by regrets that the work could not have been completed sooner, indicates that there was difficulty in finding adequate time for it.

Your reporter therefore suggests that for the coming year some two or three constituents only be determined, as the ether extract, with which the determination of the moisture is easily combined, and possibly the fiber also, and that at the most two substances be sent out, or perhaps even only one, as some coarse fodder, that being the kind of material upon which there is the most serious disagreement.

Two distinct purposes may be accomplished by this analytical work that the association is doing; one to learn what methods will give concordant results when manipulated by experienced and careful analysts; the other to afford opportunity to the Experiment Stations to test the reliability of their less experienced assistants in the laboratory. If the accomplishment of the first purpose is the only one sought for, and the work is therefore done only by experienced analysts, we may hope to make some decided progress from year to year, and eventually attain the desired goal. Methods of analysis may then be laid down which we can be assured will give concordant results if properly carried out, or else we shall have learned that such methods are unattainable. In either case we shall have completed our work.

If the second purpose is the one to be accomplished, your reporter does not see what is to save us from going on from year to year as we have been going in the years past, making very slow progress towards definite results, because at least some of the work, while perhaps as good as could be expected for its kind, is not of the kind that helps us to decide whether a method is to be accepted or rejected, because it is not experienced work, and therefore is not reliable work for the purpose in view.

Your reporter therefore recommends that, at least so far as concerns this branch of our work, the coöperation be sought of only a small number of analysts, say ten or twelve, experienced in the analysis of fodder, or of unquestionable reliability in any kind of agricultural chemical analysis, rather than to extend the invitation to all experiment stations. All the results sent in would then be useful, and in equal degree.

Your reporter also recommends that comparative tests be made of Patterson's purification of the ether extract by animal charcoal.

Your reporter further gladly accepts the recommendation made by a member of the association that besides making the ether extraction of the substance dried in hydrogen, it be made also on the substance as received.

It was directed by the association that all samples be sent out in sealed glass bottles, and that reports be sent in on the analysis of the substance as received, thus controlling the determination of the moisture as well as the other constituents determined.

Mr. Huston presented the following paper:

NOTES ON THE ANALYSIS OF CATTLE FOODS.

By H. A. HUSTON.

The following investigations were undertaken as preliminary to a more extended study of the present methods of cattle food analysis. The object in view was to determine—

- (1) The influence of complete or nearly complete drying on the amount of crude fat extracted by absolute ether and petroleum spirit.
- (2) A comparison of petroleum spirit and absolute ether as solvents of crude fat.
- (3) The influence of water on the amount of the ether extract.
- (4) The influence of small amounts of alcohol on the amount of ether extract.
- (5) The effect of reversing the order of application of the solvents used to determine crude fiber.
- (6) Study of the temperature to be used in the final drying in the determination of ash.

The material used was the set of samples sent out by the cattle food reporter of the Association of Official Agricultural Chemists, 1889-'90, viz: Hay, wheat, middlings, linseed meal. The sample of clover is one raised on the farm of the Indiana Agricultural Experiment Station.

The hay contained 9.23 per cent water, the middlings 9.63 per cent, the linseed meal 7.81 per cent, and the clover 11.25 per cent. The results are for these air dried substances. The solvents used, the time and temperature of drying are stated in the table. The dryings in the desiccators were at the room temperature during the winter, with thermometer ranging from 55° to 75° F. Each sample was in a separate desiccator over C.P. sulphuric acid. The material was on watch glasses, and was weighed from time to time, and was protected from the air during the weighing. The first weighing was made after twenty days, and over 90 per cent of the water was removed in this time. The duplicates, however, varied too widely to make this a desirable method for determining water. Experiments on mixed hay and clover showed that the drying is nearly complete in seven days over sulphuric acid, and

that calcium chloride is not suitable for such work. The drying in hydrogen was conducted in a bath of hot water boiling at 100° C. The material was contained in glass tubes 19 centimeters long and 1.5 internal diameter, with a small tube 1 centimeter long sealed to the bottom. This small tube was used to make the connection with the hydrogen-distributing apparatus which had an independent stopcock for each of the eight tubes which it supported.

The time of extracting was forty-eight hours in all cases excepting the clover. The clover was extracted twenty-four hours. In the other cases the material was extracted for twenty-four hours, and the amount of extract determined. It was then extracted for another period of twenty-four hours, and the sum taken as the extract. Soxhlet's apparatus was used throughout. Part of the extractors were of the ordinary type, with cork joints, and part were of my own design, with glass joints throughout. Repeated blank experiments failed to give any residues where cork joints were used. The condensers were about 1 meter long, and the tops were closed with closely fitting inverted test tubes. The tubes in which the material was dried were placed in the extractors, plugs of thoroughly extracted absorbent cotton being used above and below the material. In petroleum spirit extractions the substances were held down by pieces of heavy glass tubing placed over the material in the containing tube. The additional space in the extractors was filled with glass rods. When the extractions were finished the tube and rods were removed and the extractor used as a recovery apparatus for the ether. In case of petroleum a special recovery apparatus was found necessary.

The ether used had been standing over metallic sodium for some months, and was distilled as needed. The petroleum spirit had been obtained by taking the fraction distilling between 40° and 50° C. on the second distillation. This is much to be preferred to that coming over between 40° and 50° on the first distillation, as the latter contains considerable material boiling between 32° and 40°, and this gives rise to considerable trouble in the extraction. The extracts were dried at 100° C. in a current of dry hydrogen.

The results appear in the following table:

Number.	Method of drying.	Solvent.	Hay.			Wheat middlings.		
			Loss on drying.	Ex-tract.	Sum of loss on drying and ex-tract.	Loss on drying.	Ex-tract.	Sum of loss on drying and ex-tract.
1	120 days in desiccator over sulphuric acid.	Petroleum spirit.....	7.225	1.425	8.650	10.665	1.752	12.417
2	do	Absolute ether	7.055	1.665	8.720	10.760	1.740	12.500
3	4 hours in hydrogen at 100° C.	Petroleum spirit.....	7.810	1.993	9.803	8.650	2.190	10.840
4	do	Absolute ether	7.658	2.210	9.868	9.570	2.422	11.992
5	48 hours in hydrogen at 100° C.	Petroleum spirit.....	8.710	1.593	10.303	9.633	0.780	10.413
6	do	Absolute ether	9.230	1.870	11.100	10.645	1.060	11.705
7	225 hours in hydrogen at 100° C.	do						
8	4 hours in hydrogen at 100° C.	Absolute ether + 3½ per cent absolute alcohol.		2.395			1.690	
9	do	Absolute ether + water equal to loss of water on drying the sample.	7.600	2.220	9.820	11.020	1.865	12.885
10	Not dried.....	Petroleum spirit.....		1.865			2.100	
11	do	Absolute ether		2.410			2.195	
12	do	Water-saturated ether, pure.		3.625			1.925	
13	do	Residue from No. 11 extracted with absolute ether + 3½ per cent absolute alcohol.		3.210 (0.800)			2.510 (0.315)	
14	do	Absolute ether + 3½ per cent absolute alcohol.		3.590			2.155	

Number.	Method of drying.	Solvent.	Linseed meal.			Clover.		
			Loss on drying.	Ex-tract.	Sum of loss on drying and ex-tract.	Loss on drying.	Ex-tract.	Sum of loss on drying and ex-tract.
1	120 days in desiccator over sulphuric acid.	Petroleum spirit.....	7.880	6.615	14.495	.....	.....	.....
2	...do	Absolute ether	7.793	6.825	14.618	.....	.....	.....
3	4 hours in hydrogen at 100° C.	Petroleum spirit.....	8.023	8.932	16.955	9.050	1.580	10.630
4	...do	Absolute ether	7.513	9.122	16.635	9.168	2.222	11.390
5	48 hours in hydrogen at 100° C.	Petroleum spirit.....	7.813	2.767	10.580	.....	.....	.....
6	...do	Absolute ether	7.705	4.847	12.552	.....	.....	.....
7	225 hours in hydrogen at 100° C.	...do .....	.....	.....	.....	11.250	1.432	12.682
8	4 hours in hydrogen at 100° C.	Absolute ether + 3½ per cent absolute alcohol.	.....	9.050	.....	.....	2.080	.....
9	...do	Absolute ether + water equal to loss of water on drying the sample.	7.630	8.610	16.240	.....	.....	.....
10	Not dried.....	Petroleum spirit.....	.....	9.385	.....	.....	1.820	.....
11	...do	Absolute ether .....	.....	9.485	.....	.....	2.885	.....
12	...do	Water saturated ether, pure.	.....	9.659	.....	.....	4.460	.....
13	...do	Residue from No. 11 extracted with absolute ether + 3½ per cent absolute alcohol.	{ 9.975 (0.495) }		.....	{ 3.995 (1.110) }		.....
14	...do	Absolute ether + 3½ per cent absolute alcohol.	.....	9.590	.....	.....	4.390	.....

In this table only the means are given. The table shows that long drying of the samples, either in desiccators or in hydrogen, results in a very marked diminution of the amount of matter extracted either by petroleum spirit or by ether. Compare No. 1 with No. 3, No. 2 with No. 4, No. 3 with No. 5, No. 4 with No. 6.

On comparing No. 3 with No. 10 and No. 4 with No. 11 it is seen that there is relatively little difference between the extract from samples dried four hours at 100° in hydrogen and from the substances in the air-dried condition. No. 9, in which the substance was first dried four hours in hydrogen at 100°, and then water added equal to the loss on drying, shows the same thing.

No. 8 seems to indicate that if the substance be previously dried the addition of 3½ per cent of alcohol to the ether makes comparatively little difference, while Nos. 13 and 14 show that in case of substances containing considerable chlorophyll the addition of alcohol makes a marked increase in the amount of extractive matter. In the same way No. 12 shows that the presence of an excess of water in the ether makes a decided increase of extractive matter in case much chlorophyll is present, but comparatively little difference in the case of other substances. No. 13 was intended to show whether the same results would be obtained by extracting the substance with two solvents successively as would be obtained on direct extraction with the second solvent, as in No. 14. In No. 13 the upper row of figures is the sum of the absolute ether extract obtained in No. 11 and the amount obtained by subsequent extraction with alcoholic ether. The lower row of figures is the amount of extract by the alcoholic ether. The results of a number of comparisons between Squibb's stronger ether and absolute ether show that in every case Squibb's ether gives an amount of extractive matter far greater than would be accounted for by the amount of alcohol present in it. The Squibb's ether had been redistilled, and the distillate left no residue on evaporation.

The column headed "Sum of loss on drying and extract" is entered to show that the reduction of extractive matter is not wholly due to loss through volatilization of material on drying.

The chief cause of the smaller amount of extractive matter in the samples submit-

ted to long drying is probably, as suggested by Dr. Wiley, a change in the cell wall by which the inner layer of nitrogenous material becomes less pervious to the fluids used as solvents. This matter is now being investigated.

The fact that long drying has the same effect in the case of fungi containing no true cellulose seems to confirm this view.

It is noteworthy that if the comparisons of extractive matter in the samples that have been dried four hours and in the air-dried samples be made on the amount extracted in the first twenty-four hours instead of in forty-eight hours, the differences almost disappear; but the ratio between the amounts dissolved by petroleum spirit and absolute ether remains practically the same.

In all cases where any examination of the material extracted during the second period of twenty-four hours was made the extract did not appear to have the properties of fatty substances; but the amounts obtained were so small as to render any complete examination impossible.

CRUDE FIBER.

The results of applying the alkali first in the determination of crude fiber showed that in every case there was a loss of time; with wheat middlings this loss amounted to six hours, and with the linseed meal to four days. In all cases a higher per cent. of fiber was obtained than by the official method, and the duplicates varied more widely.

ASH.

In the determination of ash I have frequently noticed that the charred mass when treated with water gives a brownish colored solution. Moreover, the drying at 110° C. would not remove all the water of crystallization should any be present, nor would it remove the brown, caramel-like substance contained in the solution. The following results were obtained, using higher temperatures:

	Per cent of ash.		
	Hay.	Middlings.	Linseed meal.
Dried at 110° C	5.42	1.07	5.64
Dried at 230° C	5.27	0.96	5.53
Ignited one to two minutes at very low red heat*	5.05	0.86	5.34

* This is the method adopted for the coming year.

Mr. Anderson presented the following paper:

EXPERIMENTS IN DETERMINATION OF MOISTURE, AND ETHER EXTRACT.

By J. T. ANDERSON.

In December of last year Professor Caldwell issued his bulletin describing "A new apparatus for drying substances in hydrogen, and for the extraction of fat." This apparatus was procured for our laboratory at once, and with it a series of experiments was instituted, some of whose results the writer deems of sufficient interest to bring to the attention of this association. It was proposed to compare the old method of drying in air with the newer one of drying in hydrogen. That the temperature might be the same in all cases, the drying, whether in air or hydrogen, was conducted in a water bath of boiling water. Cotton-seed meal and German millet were the substances selected for the experiments. With the cotton-seed meal the mean of six determinations of moisture by drying in air gave 8.81 per cent. The mean of seven determinations in hydrogen was 9.73 per cent, making a difference of 0.92 per cent in

favor of drying in hydrogen. With German millet similar results were obtained. The mean of four determinations in air gave 10.53 per cent H_2O , in hydrogen 10.73 per cent H_2O , a difference of 0.20 per cent in favor of drying in hydrogen. These results were not unexpected, but are given as confirmatory of the opinion generally entertained, that we do not get the full amount of moisture in feed stuffs when we dry them in air, since the loss of weight after drying does not represent the weight of the moisture driven off.

Some interesting facts were elicited in the matter of determining the ether extract. As a matter of convenience it has been our custom in the Alabama laboratory to determine the ether extract by drying and weighing the residue of fiber, carbohydrates, etc., instead of the product extracted by the ether. This writer undertook some experiments recently to test the validity of this variation from the prescribed method. As in the moisture determinations, cotton-seed meal and German millet were the substances used. In all cases the extraction product and the residue left after the extraction were dried to a constant weight in the same water bath of boiling water. With cotton-seed meal the following are the means of seven determinations of ether extract. From weighing the fiber residue, 7.63 per cent; from weighing the extraction product, 7.45 per cent. Six samples of German millet, treated in the same way, gave: From weighing the fiber residue, 3.95 per cent; from weighing the extraction product, 3.57 per cent. In every case a larger per cent of ether extract was obtained by weighing the fiber residue. This is believed to be due to the volatilization of ethereal oils in the process of drying the product extracted by the ether. What will be the effect of drying both the residue and the extraction product in hydrogen instead of in air is a question of considerable interest.

Mr. Anderson exhibited and explained an extraction apparatus used by himself with good results.

Mr. Wiley presented the following paper, from the Chemical Division, Department of Agriculture.

ON THE METHODS OF ESTIMATION OF THE FATTY BODIES IN VEGETABLE ORGANISMS.

By WALTER MAXWELL.

These investigations have been conducted with the purpose of acquiring some further data showing the comparative proportions of matters which become separated from vegetable organisms by extracting with pure ether in variable durations of time. It has further been attempted to determine whether the whole of the substituted glycerides, or lecithines, do become separated by direct extraction with ether only.

The materials used in the work were pulverized to the greatest state of fineness, and the extractions were made with the Knorr extraction apparatus. The calculations are reduced to the standard of water-free material.

(a) The preliminary experiments which were made in order to establish the proportions of the vegetable matters separated by the action of pure ether in different durations of time are illustrated by the following results:

Cotton Seed.

Time.	Weight of material.	Weight of extract.	Per cent.
<i>Hours.</i>	<i>Grams.</i>	<i>Grams.</i>	
8½	4	1.472	37.39
10	4	1.491	37.87
15	4	1.511	38.38

These results give the average of a great number of analyses. Although an increased amount of substance becomes separated with an increased duration of the period of extraction, the proportion is small; and it is not apparent that the greater duration of time causes an increase in the fatty bodies only, as other matters can be affected by a very protracted boiling. For these reasons it has been resolved to estimate the amounts of the fatty bodies separated by extraction with pure ether in a duration of fifteen hours.

In considering the estimation of the proportions of glycerides and substituted glycerides which are contained in the ether extract, the presence of other bodies, which have been removed with the ether, make it impossible, in the absence of an absolute analysis of the extract, to determine accurately the comparative relations of those fatty bodies. The ether extractions of plant matters contain variable proportions of cholesterin and of, in some instances, solid hydrocarbons, which may constitute several per cent of the extract. However, although the percentage of glycerides can not be definitely estimated, the lecithines or substituted glycerides may be determined with absolute accuracy, as the estimation of these bodies rests upon the proportion of phosphorus present in the ether extract. The extract is combusted with mixed alkali salts by which the phosphorus present in the organic form as lecithine becomes fixed as an alkali phosphate, and is then determined as magnesium pyrophosphate, and the latter body being multiplied with the known Hoppe-Seyler factor, gives the exact amount of lecithine.

A further series of extractions was made of the pulverized cotton seed with pure ether for a period of fifteen hours and the total extract determined. The proportion of lecithine contained in the extract was estimated by the method already given, the residue of the extract being considered as glycerides and other bodies. The average of eight analyses gave the following results:

	Per cent.
Extract	38.46
Glycerides, etc.	98.84
Lecithines	1.16

(b) It will be shown that the proportion of substituted glycerides stated, 1.16 per cent, does not represent the total lecithine present in the cotton seed.

The observation was made simultaneously by Prof. E. Shulze, Zurich, and W. Maxwell, Harvard College, that the substituted glycerides do not become wholly separated by extraction with ether, even in a great duration of time. It was found that if the material which had been already extracted with ether were further extracted with absolute alcohol another portion of substituted glycerides was obtained, which in most instances was greater than the amount separated by the ether. The process of the alcohol extraction consisted in merely extracting the material already treated with ether and evaporating off the alcohol and reextracting the alcohol extract residue with ether. The reason for taking up the lecithines out of the alcohol extract was that it has been observed that those lecithines which were originally insoluble in ether became soluble in that menstruum when previously acted upon by alcohol. The use of ether was further made in order to avoid any small portion of inorganic phosphates which might have been removed from the vegetable material by alcohol. It was found, however, that only a mere trace of mineral phosphates had been separated by the action of the alcohol.

The amount of the ether extraction of the alcohol extract in one hundred parts of the vegetable material with the proportion of lecithines was as follows:

	Per cent.
Extract	2.3
Lecithines in extract	16.6

A further comparison indicates the following:

	Extract.	Leci- thines.	Glycerides, etc.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Ether	38.46	1.16	98.84
Ether and alcohol	40.76	2.30	97.69

The proportion of lecithines to the total fatty bodies contained in the cotton seed is very small, yet it is seen that about 50 per cent of those substituted glycerides are left in the material after extraction with ether for a period of fifteen hours. If certain other varieties of seeds be considered, such as the legumes, pea, vetch, bean, Boston bean, etc., it is found that the total ether and alcohol extracts of those seeds are composed of lecithines varying from 25 to 45 per cent. It is thus apparent that, in the examples of seeds given, as far as 20 per cent to 25 per cent of the total fatty bodies can remain unseparated and undetermined when the material is extracted with ether only.

Mr. Wiley explained certain new forms of apparatus used in his laboratory as follows:

SOME NEW FORMS OF APPARATUS USED IN AGRICULTURAL CHEMICAL ANALYSIS.

A NEW FORM OF EXTRACTION APPARATUS.

In Fig. 6 is represented a new form of extractor, devised and made by Mr. A. E. Knorr, of my division, in which the use of corks or ground glass connections of any kind is entirely dispensed with. The operation of the apparatus will be understood by a brief description of its parts.

A is the flask containing the solvent, W a steam bath made by cutting off the top of a Winchester quart bottle and inverting it and conducting the steam into one of the tubes shown in the stopper while the condensed water runs out of the other. The top of the bath is covered with a number of concentric copper rings, so that the opening may be made of any desirable size. B represents the condenser, which is a long glass tube on which a number of bulbs have been blown, and which is attached to the hood for holding the material to be extracted, as represented at B', making a solid glass union. Before joining the tube at B' the rubber stopper which is to hold it into the outside condenser of B is slipped on, or the rubber stopper may be cut into its center and slipped over the tube after the union is made. In case alcohol is to be used for the solvent, requiring a higher temperature, the flask holding the solvent is placed entirely within the steam bath, as represented at A'.

A more detailed description of the different parts of the apparatus can be seen by consulting Figs. 7, 8, and 9. In A, Fig. 7, is represented a section of the flask which holds the solvent, showing how the sides of the hood containing the matters to be extracted pass over the neck of the flask, and showing at S a small siphon inserted in the space between the neck of the flask and the walls of the hood for the purpose of removing any solvent that may accumulate in this space. A view of the flask itself is shown at A'. This flask is made by taking an ordinary flask, softening it about the neck and pressing the neck in so as to form a cup, as indicated at A', to hold the mercury which seals the union of the flask with the condenser. The flask is held in position by passing a rubber band below it, which is attached to two glass nipples blown onto the containing vessel, as shown in Fig. 6b. The material to be extracted may be contained in an ordinary tube, as shown in Fig. 8, which may be made from a test tube drawn out, as indicated in the figure, and having a perforated platinum disk sealed in it at D. The containing tube rests upon the edges of the

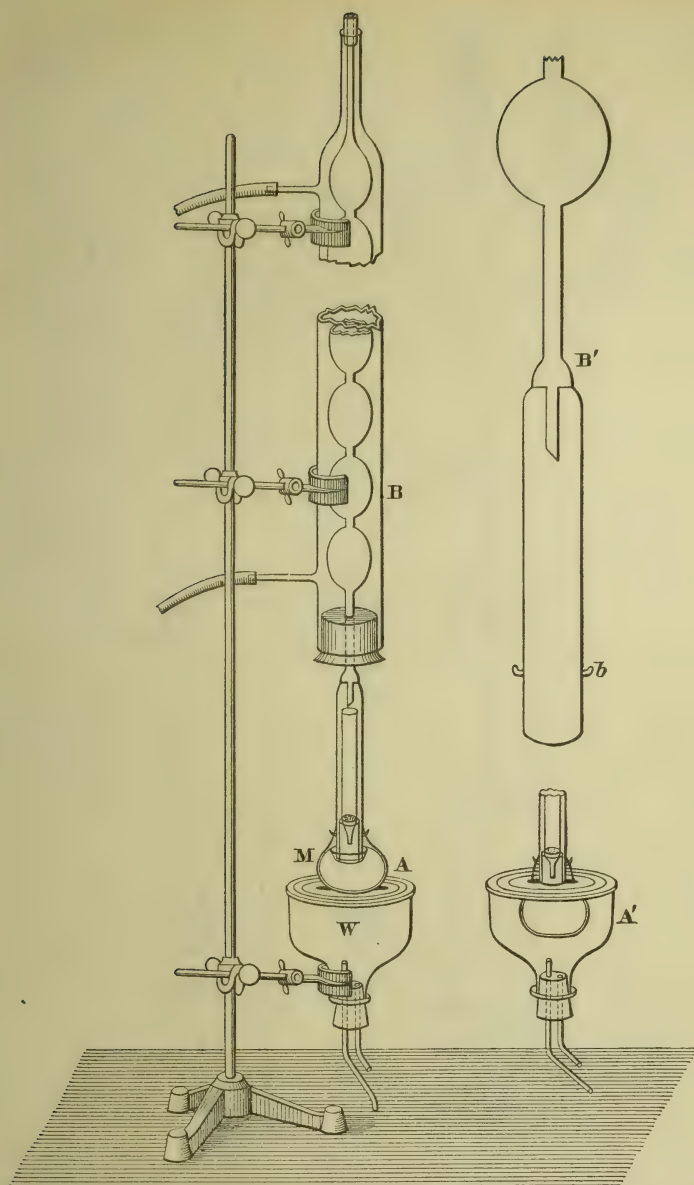


FIG. 6.

flask containing the solvent by means of the nipples shown at *t*. If a siphon tube is to be used, one of the most convenient forms, and one which is used exclusively in my laboratory, is shown in Fig. 9, in which the siphon lies entirely within the extracting tube, thus being protected from breakage. By means of this apparatus the extractions can be carried on with a very small quantity of solvent, there being scarcely any leakage, even with the most volatile solvents, such as ether and petroleum. The apparatus is always ready for use, no corks are to be extracted, and no ground glass joints to be fitted. The apparatus has been in use for about a year, and has given most perfect satisfaction.

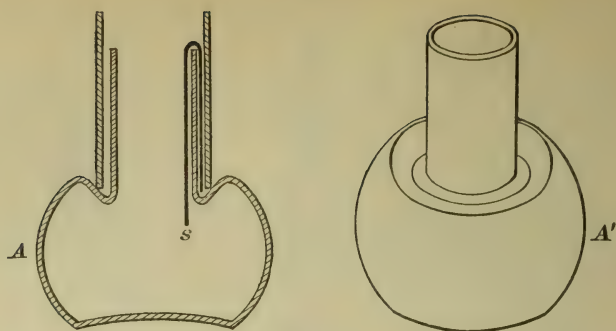


FIG. 7.

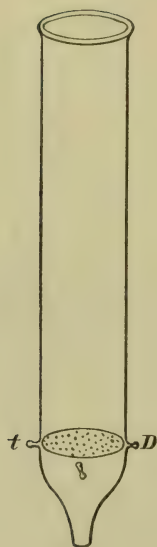


FIG. 8.

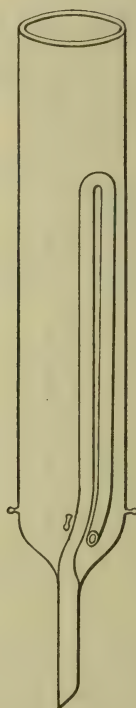


FIG. 9.

For the purpose of recovering the solvent the apparatus shown in Fig. 10 is used. W represents the steam bath, A the flask containing the solvent to be recovered, which is held in the usual way, connected with the condenser B by the bent tube, as shown, the condenser being connected with the flask R at G, and sealed into a cup similar to that used in the extractions at M by mercury.

In all cases after the apparatus is adjusted mercury is poured into the cup formed by the depression in the flask, thus sealing it completely and permitting the extraction to go on in an apparatus without a joint of any kind except that formed by the mercury in the cups.

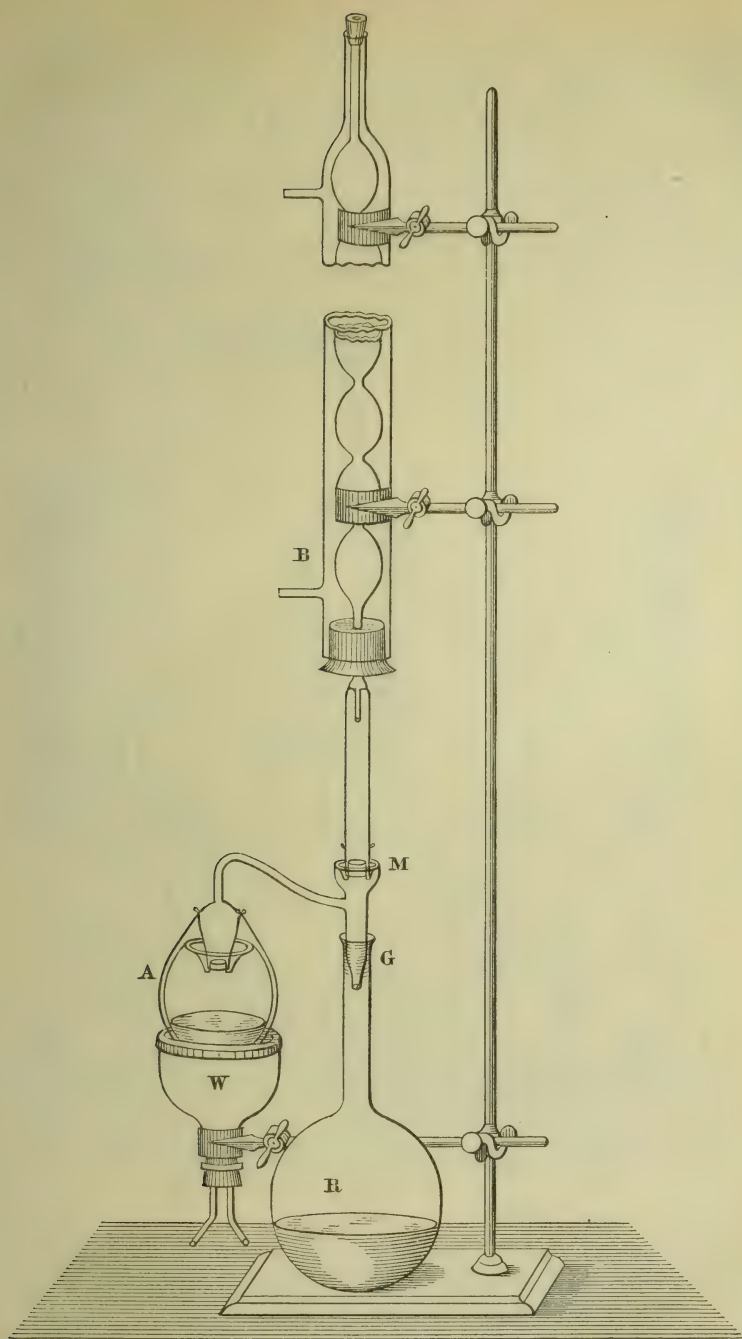


FIG. 10.

APPARATUS FOR DRYING IN HYDROGEN.

For the purpose of drying materials contained in flasks and tubes in a current of hydrogen the apparatus shown in Fig. 11 is used. This apparatus consists of a circular box, B, conveniently made of galvanized iron, having a movable cover, S, fitted for the introduction of steam into the interior of the apparatus. Condensed steam escapes as water at W. A stream of perfectly pure and dry hydrogen enters at H, passes up through the material to be dried, down through the bulb V, containing sulphuric acid, and following the direction of the arrows through the rest of the apparatus. The stream of hydrogen is thus completely dried by passing through bulbs containing sulphuric acid, and passing from one piece of the apparatus to the other.

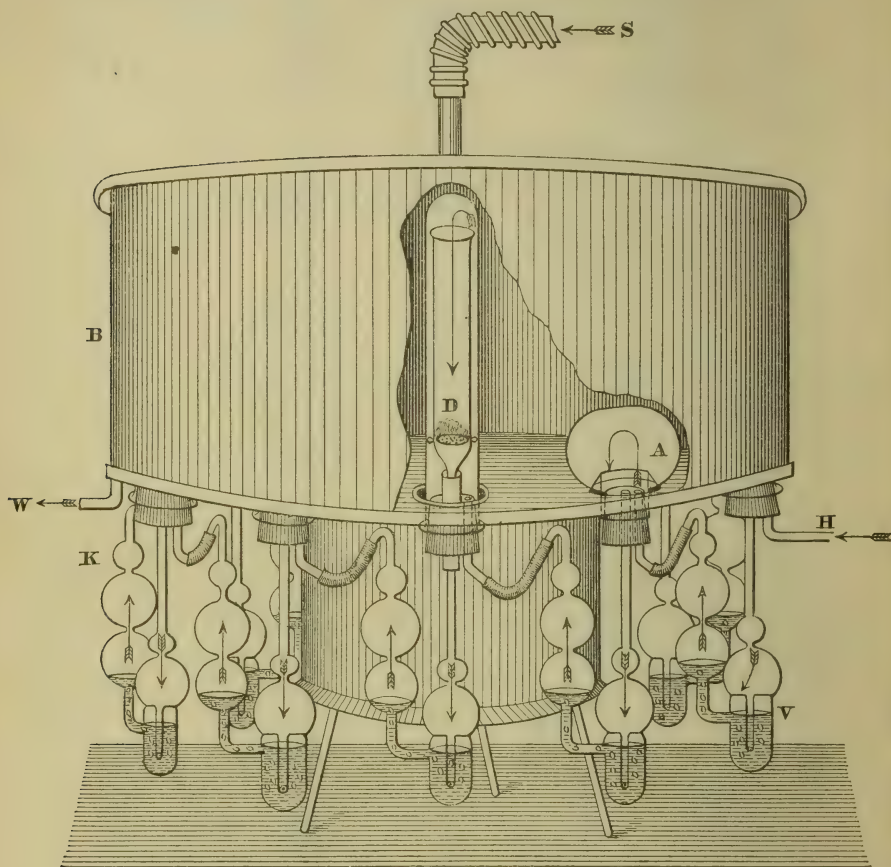


FIG. 11.

A, represents a flask such as is used, with the extraction apparatus described. The apparatus which we have used will hold eight tubes or flasks at a time, and thus a single stream of hydrogen is made to do duty eight times in drying eight separate samples. The great advantage of the apparatus is in the fact that we are absolutely sure of the stream of hydrogen passing over and through the substance to be dried. In order to prevent any sulphuric acid from being carried forward into the next tube we have decided to place an additional bulb at a point, K, above the sulphuric acid, and in this bulb solid pieces of soda or potash will be placed.

We have used this apparatus for nearly a year, and have not had any accidents from sulphuric acid being carried forward, and there is no danger, provided the stream of hydrogen is kept running at a slow rate. If, however, by any accident the stream of hydrogen should be admitted with great rapidity, particles of the sulphuric acid might be carried forward and spoil the next sample. To avoid any such accident as this the proposal to introduce the potash bulb has been made. The apparatus works with perfect satisfaction, and it is believed that when properly adjusted check weighings can be made by weighing the bulbs, showing their increase in weight, which will give the volatile matter, and weighing the flasks or tubes, which will show the loss of weight. The only chance for error in weighing the bulbs is that some of the volatile matter may be material which is not dissolved in sulphuric acid, and is thus carried on and out of the apparatus. The blackening of the sulphuric acid in the bulbs in the drying of all forms of organic matter shows that the loss in weight of such bodies is not due to water alone, but to organic volatile substances, which are capable of being decomposed by the sulphuric acid, thus blackening it.

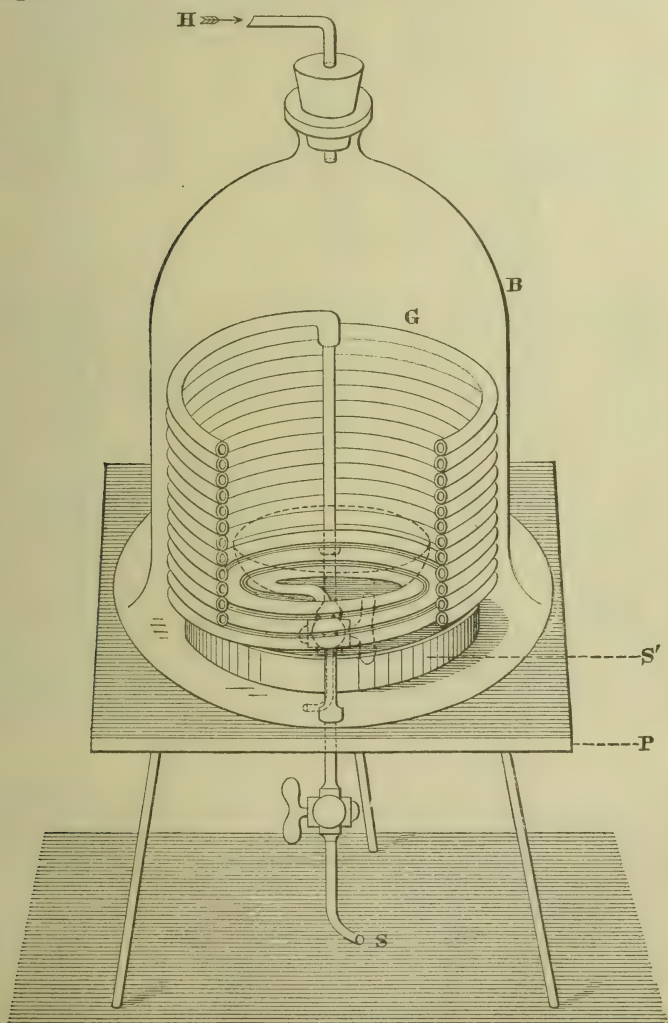


FIG. 12.

Fig. 12 shows another form of apparatus for drying in hydrogen, which is used for the purpose of drying substances in flasks, dishes, etc., in considerable numbers. It consists of an iron plate, P, smooth on upper surface, supported on three legs. This plate carries two perforations in the center, one for admitting the steam S, and the other for carrying off the products of condensation. Over the iron plate is placed a large bell-jar B, into which a stream of perfectly dry and pure hydrogen is admitted at H. The bell-jar fits snugly on the iron plate, and the stream of hydrogen is first admitted rapidly until all the air within the bell-jar is expelled. After this the stream of hydrogen is admitted slowly, so as to simply supply the place of hydrogen which may be lost by diffusion or leakage between the edges of the bell-jar and the iron plate. Within the bell-jar the copper or brass coil C is found, consisting of small brass or copper tubing coiled over the bottom at a distance of about 4 or 5 centimeters from the iron plate and then continued in a coil up the sides, as shown in the figure. Beneath this coil is a vessel, S', containing strong sulphuric acid. The vessel to be dried, as shown in the figure, is placed within the coil, and is thus kept at a temperature of steam at whatever pressure it may be, while at the same time a slow current of dry hydrogen is passing over it. The space within the coil may be entirely filled with samples to be dried. The vapor of water, being heavier, rapidly falls through the hydrogen and is absorbed by the sulphuric acid in S. By varying the pressure of the steam admitted the temperature of air within the coil may be kept at various points from 98° up to even 103°. It is not difficult to secure within this coil the temperature of boiling water, and thus have the dishes containing organic matter dried in a perfectly dry atmosphere of hydrogen.

DEVICE FOR RECOVERING SOLVENTS FROM OPEN DISHES.

It often happens that materials which are dissolved by the ordinary solvents in use are to be collected in open dishes in order that their properties may be studied. At the same time large quantities of solvent must be used, and it is desirable to have some method of recovering such solvents. The device shown in Fig. 13 has been found to work excellently well for this purpose. It consists of a steam bath, W, and a bottle, B, with the bottom cut off, resting on an iron dish P, containing a small quantity of mercury, enough to seal the bottom of the bottle. The dish containing the solvent is placed on the mercury, and the bottle placed down over it, forming a tight joint. On the application of steam the solvent escapes into the condenser C, and is collected as a liquid in the flask A. In very volatile solvents the flask A may be surrounded with ice, or ice-cold water passed through the condenser. When an additional quantity of the solvent is to be added to the dish for the purpose of being evaporated it is poured in the funnel F, and the stopcock H opened, which allows the material to run into the dish in B without removing the bottle. In this way many liters of the solvent may be evaporated in any one dish, and the total amount of extract obtained together. At the last the bottle B is removed, and the extract which is found in the dish is ready for further operations.

APPARATUS FOR EVAPORATING IN VACUO.

Many of the operations in the laboratory require the evaporation of the material in vacuo. Especially is this true where the recovery of organic matters in solution is desired, which are easily altered at a high temperature. The evaporation is effected by the apparatus represented in Fig. 14. W is a water bath or steam bath, in which is placed a stout copper hemisphere, B, with flat edges. This hemisphere, B, is connected by a gum gasket, C, with a bell-jar, G, and this bell-jar is connected by means of the stopper through the stopcock H, with the safety flask, A, and the vacuum pump connected with E. An indicator, I, shows the amount of vacuum. The liquid to be evaporated is placed in B, the pump connected with E is started, and when the air is exhausted to the proper degree the water bath is heated or steam is admit-

ted to it until the liquid begins to boil. By means of this apparatus in my laboratory we are able to carry on evaporation for any length of time with a vacuum of from 26 to 27 inches.

We have a somewhat larger one than this which we use for larger quantities of liquid, which is furnished with a regular condensing apparatus, such as is used with large vacuum pans. This apparatus has also given the very best results in practice.

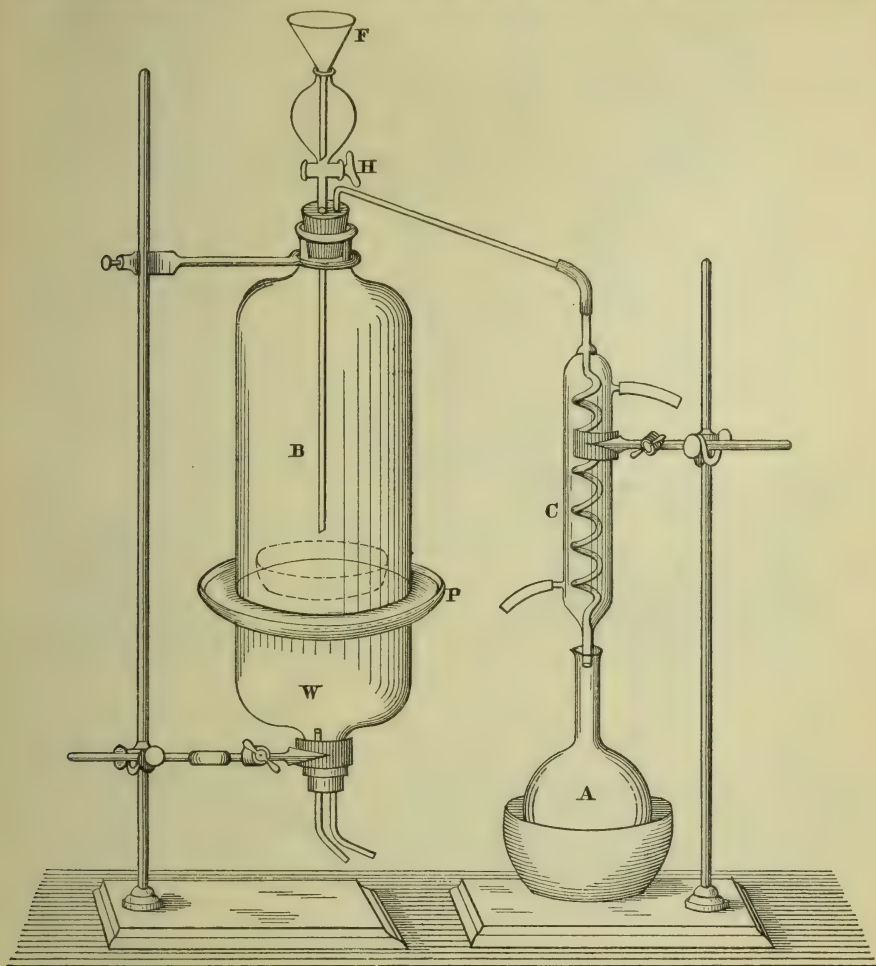


FIG. 13.

Where small quantities of liquid are to be evaporated the following device, shown also in Fig. 14, has been found to be successful. A large test tube, F, of strong glass is used. The material to be evaporated is placed in this test tube, and it is connected by means of a rubber tube, V, with the safety bottle A, and the exhaust pump connected with E. A small glass tube, *t*, drawn out to a fine point, extends, as shown in the figure, to the bottom of the test tube. This is furnished with a rubber tube and a clamp at K. This clamp can be set so as to admit a small stream of air through *t* to the bottom of the test tube. This air keeps the liquid to be evaporated in constant motion, and thus prevents bumping, and at the same time greatly aids the evaporation. The amount of air entering can be so regulated by the clamp K as not

to interfere with the vacuum. By means of this simple apparatus very small quantities of a liquor can be evaporated very rapidly to a very small bulk, and the substances sought are left in the tube ready for examination. We have found this simple form of apparatus to be especially valuable in the obtaining of vegetable extracts, such as sugars, etc., in a pure state and in a proper form of concentration for

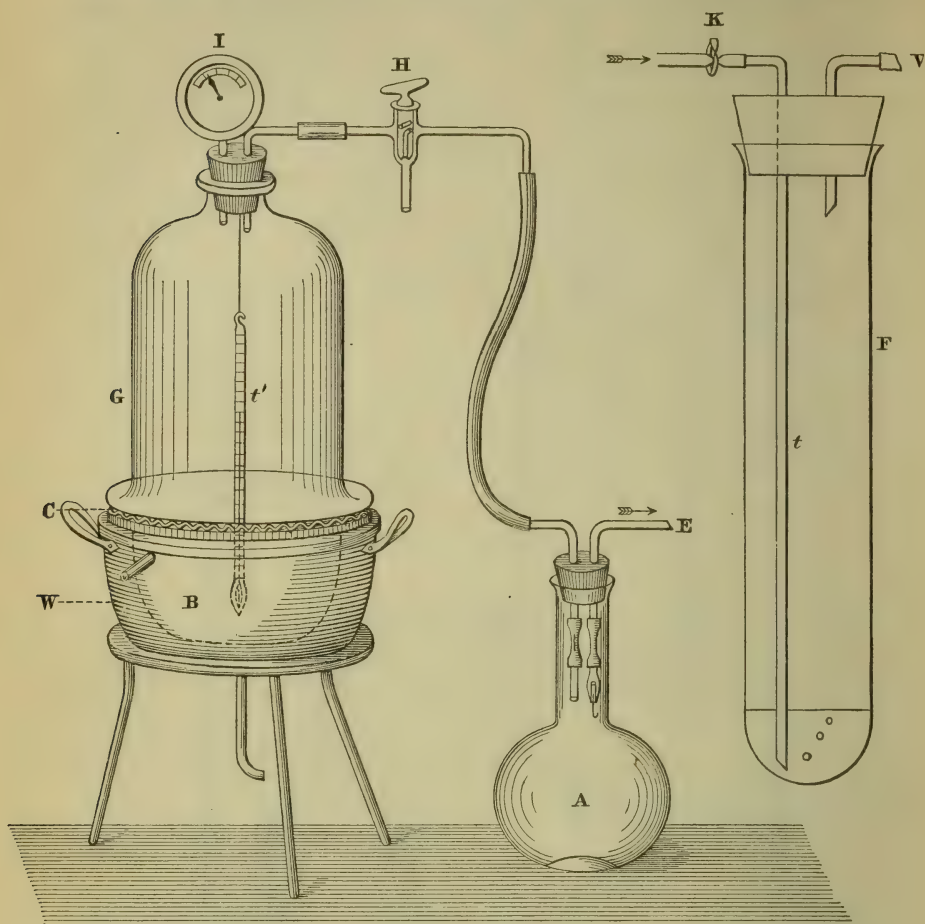


FIG. 14.

crystallization. I use in my laboratory, instead of a small Sprengl pump, a large vacuum pump connected with a reservoir in which a constant vacuum of about 26 inches is maintained. This reservoir connects with all the different desks in the laboratory, so that an apparatus of this kind can be used at any point in the laboratory at once by simply fitting up a test tube as described.

The apparatus just described has given such excellent results in use as to merit a more extended description. The smaller apparatus as used by me is illustrated in Fig. 15. A is the heavy test tube containing the liquid to be evaporated, and H is the supply beaker from which A is fed through C as the evaporation proceeds. A three-way stopcock, *a*, permits either the liquid in H to be drawn into the tube or air only, at the pleasure of the operator. In practice I have found it better to replace the three-way cock with a T-tube with two rubber connections carrying a screw clip. The quantity of liquid or air thus introduced can be exactly controlled. It is best to

establish a continuous feed from H of such volume as to maintain nearly a constant level in A until the liquid is all out of H. It is evident that A may be replaced by any shaped flask or tube capable of resisting the pressure of the air.

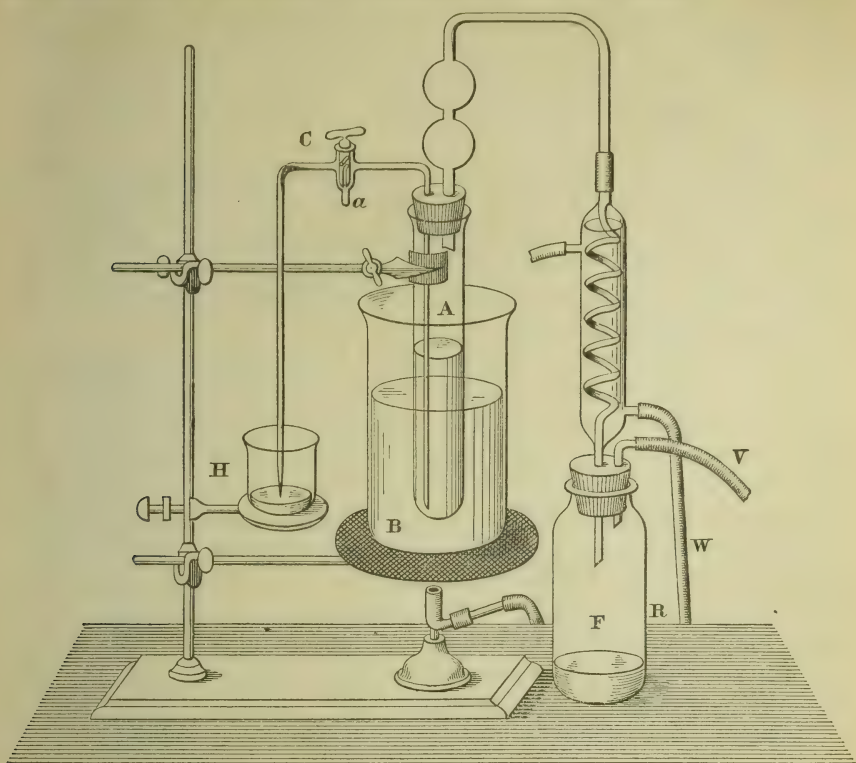


FIG. 15.

The two bulbs blown on the connecting tube between the condenser and A serve to prevent any loss of material from foaming or too violent ebullition. Foaming is very apt to occur if the feed from H be intermittent and a large quantity of liquid be drawn into A at one charge. F is a strong flask for receiving the water of condensation. W is connected with the water supply for keeping the condenser cool, and V leads to the vacuum pump. The water in the beaker B should be kept only a few degrees above the boiling point of the liquor in A. The stream of air admitted through *a* should be sufficient to prevent bumping and strong enough to hasten evaporation by carrying off the aqueous vapor.

Mr. Huston said that he had a paper by Dr. Stone, entering into the consideration of nitrogen-free extract; he would present it later on.

The president stated that the consideration of the recommendations made by the reporter was now in order, to be followed by any other recommendations which might be offered. The reporter would present his recommendations severally.

Mr. Caldwell said that he did not care to offer his first recommendation in the form of an amendment; it was rather a suggestion to the reporter that the method be tested during the year to ascertain its importance.

The second recommendation was in regard to the ether extract; it was proposed to either simply use the portion in which moisture had been determined as above, or dry 2 grams four hours.

Mr. Huston said that he thought the moisture and the ether extract could not be determined together with any degree of accuracy. A sample in which the extract dropped from 9 to 2 per cent on drying would not answer.

Mr. Caldwell said that the point made was very important. Was the association ready, however, to make the suggested change in the official method? If the association thought best, he was perfectly willing to make it, but it should be remembered that this was the official method by which the analyses were to be made during the year. The change was a radical one.

Mr. Huston said that, as he understood it, the analyst was to take 2 grams dried four hours or the sample in which the water had been determined. He did not see that these things were at all alike. He might be out of the way in his method of determining water, and perhaps heated it too long, but he had had cases in which it took over two hundred hours in a stream of hydrogen to get all the loss, and he was certain that in such a case one could not get ether extract; and if a water determination was to be made and all the volatile matter reduced to minimum weight before extraction, the variation would range from 5 per cent up to 80 per cent, but he did not believe that it would be possible to get out more than 80 per cent ether extract. He thought it might be desirable to omit the first clause: "Dry 2 grams of the substance four hours," and so on. He believed it would be a mistake to say that the ether extract could be made in the same sample that was used for the moisture.

Mr. Caldwell said that he understood it to be Mr. Huston's opinion that drying for four hours would not fully expel the moisture, and that the slight amount left would make a difference as compared with the result obtained by fully drying. Of course there was a very small quantity of moisture left after drying four hours, and his supposition had been that whether the drying was continued for four hours or for twelve hours the result would be practically the same as with ether.

Mr. Huston said that that was not his idea; the methods might work out that way in the end, but he thought that the water which was left had comparatively little to do in causing the trouble, and cut a comparatively small figure in the fat extractions, even in cases with water saturated ether worked forty-eight hours. The chief sources of trouble were the volatilization of some matter soluble in ether and what was called provisionally the change in the cell wall. If the association was not ready to leave out the four hours drying, that might stand, but as for the other matter—the sample used for getting the water—that was much worse than the four hours, and should not be inserted. Most men would not admit that a four hours' drying was sufficient to determine

the water. The fat extract in linseed meal would be worthless, and he thought that nothing ought to be inserted which would make the methods worse than at present.

Mr. Caldwell said that he would withdraw the recommendation.

Mr. Wiley said that, in his opinion, the object of a cattle-food analysis should be to determine as nearly as possible the quantity of a given substance present in the food. The use of anhydrous ether was recommended, and the object of the recommendation to dry the substance in hydrogen was that the water present in the sample should be removed so that the ether used for the extraction should remain anhydrous. If by this process there was really a diminution of the amount of substance extracted by the ether, and there evidently was, then was this additional substance due to the action of the water entering the ether on bodies soluble in water in the sample? If so, the analyst would get a portion, say, of carbohydrates. He believed that the minute portion of water which would enter ether through the sample was wholly insufficient to act on water-soluble bodies in the sample, and that the increase resulting from the use of ether was due solely to the extracting of bodies soluble in ether; these were more accessible to ether in the undried state. He thought that Mr. Huston's work showed conclusively that there was a loss of the very substance which it was desired to get by the previous drying, and nearly all would agree—his own experience upon the point was positive—that four hours' drying in hydrogen was wholly insufficient for estimating the volatile matter at the boiling point of water; the substance must be dried longer. Therefore the introduction here of this four hours' work would be, in his opinion, not only unnecessary but hurtful, and would not serve for the estimation of water. If the water was estimated there would be an enormous diminution of the amount of matter soluble in ether. Drying only four hours, less damage would be done, but a portion of the fatty bodies would certainly be rendered inaccessible to ether. He would like to see it recommended that the substance be dried four hours in hydrogen—making that specific; then strike out the *or*, as suggested by Mr. Huston, making it read, "in the sample in which the water has been determined;" and then recommend that it be also extracted in the air-dried substance. While conservative himself, and personally convinced that the four hours' drying was hurtful, he would not ask to have it stricken out without a further trial. He moved that the recommendation of the reporter be so amended as to direct that the ether extract shall be made with absolute ether on a substance dried four hours in ether at the boiling point of water, etc. The ether extract on the air-dried substance in the samples sent out to be also reported upon.

Mr. Woods said that there seemed to be two considerations in view in getting up the program, one being that of the methods which should govern the work, and the other the matter of testing the few samples sent out. If the proposed methods were to be applied only

to the samples received from the reporter, that would be one thing; it would be a wholly different thing used as a working scheme for the year. In his own work it was impossible, or impracticable, to carry dryings in coarse fodders to anything like the point at which they would cease losing weight. He thought that working schemes and schemes for experiments should be kept distinct, and that the recommendations of the reporter should not be adopted as the official method.

Mr. Caldwell said that he agreed with Mr. Woods, and had, therefore, said nothing about any change in the sample. He believed it would be well to keep the official method for the next year entirely distinct, and to make it as simple as possible, involving no more manipulation or drying than was necessary. Then the various changes desired might be added at the end.

Mr. Wiley said that he would withdraw his motion; he had not looked at the matter in the light now presented. He agreed with the last two speakers that it was better to adopt a method for general work, and afterward recommend such important methods as should be put forward for comparison. He moved that in the official method, under the head of "Moisture" (page 226), the water be determined by drying four hours in a current of hydrogen. Carried.

Mr. Anderson asked whether the hydrogen passed through the substance was previously heated.

Mr. Wiley said that the specific heat of hydrogen was so low that it was useless to heat it before passing through.

Mr. Huston said that it seemed to him important that in the official method some guide should be given as to the rate at which the hydrogen was to go through; he passed it through at the ordinary combustion rate.

The president said that no amendment of the method for pure ash was recommended.

Mr. Woods said that for practical working he would move to amend the method by striking out the part relating to determination of carbon dioxide.

The president stated the motion to be that all after the words "dry the whole at 110° and weigh," in the method for pure ash (page 226), be stricken out. Carried.

Mr. Woods said that in his experience it had proved to be simpler and more accurate to char after the evaporation at a low red heat than to dry at a temperature of 110°. He had rarely failed to find some organic matter present, however careful he had been in the first charring. He moved to further amend the method for pure ash by striking out the words, "dry the whole at 110°," and substituting in place thereof the words, *and heat to low redness until the ash becomes white*.

The amendment was agreed to, and, on motion, the method for determination of pure ash, as amended, was adopted.

At 12.30 p. m. a recess was taken.

AFTERNOON SESSION, FRIDAY.

The convention was called to order by the president at 2 p. m.

Mr. Wiley said that on the preceding day one point in the matter of butter analysis had been passed over. Mr. Knorr would call attention to the method of calculation for specific gravity instead of weighing.

Mr. Knorr said that his reason for undertaking the calculation referred to was that in determining the amount of water contained in the flask at the boiling temperature he had been unable to obtain concordant results, owing to the formation of very minute bubbles of vapor of which he could not get rid. He therefore thought it more accurate to calculate the weight of water at 100° in the flasks, which was done by a formula obtained from the tables of Landolt, and now placed upon the blackboard for the benefit of those present who had not the tables. (See page 197 in methods).

The president said that he had been asked at what point in the order of business resolutions should be submitted, and he would state that these would properly come in under the seventh order of business as set forth in the programme which had been agreed to, namely, business meeting, election of officers, etc. General resolutions could be handed to the secretary at any time, to be taken up when reached in the regular order.

He wished also to state his own pleasure and that of the association at seeing present so many chemists who were not members of the association. In regard to their standing, he had referred to the constitution, which contained the following clause:

All analytical chemists and others interested in the objects of the association may attend its meetings and take part in its discussions, but shall have no vote in the association.

Basing his decision upon this clause, he would hold that such chemists were entitled to make and discuss motions, and otherwise take part in the proceedings of the convention, with the single exception that they could not vote.

The continuation of the subject of cattle foods was now in order.

Mr. Caldwell said that the next matter to be taken up was that of the ether extract. The direction was to dry 2 to 4 grams of the substance in a current of dry hydrogen at the boiling point of water. It would then, as he understood, read as follows:

Exhaust the residue from the determination of moisture, or another portion dried in the same manner, with anhydrous and alcohol free ether until extraction is found by test to be complete.

He moved that the method as so modified be made the official method for the ensuing year. Seconded.

Mr. Wiley inquired whether, in the opinion of the reporter, it would be practicable to fix a definite number of hours. Some substances would continue indefinitely to give up material to ether, and under the

rule proposed the extraction would never come to an end. Uniformity and applicability were to be sought, and if there could be substituted a definite number of hours as the time in which the extraction should take place, the results would, he believed, be more satisfactory. However, he had not done enough work upon food stuffs to know all about the matter, and would be glad to have the reporter's opinion and that of others who had large experience in that line.

Mr. Caldwell said that the suggestion was a very good one, and it was for that reason that he had called the attention of the association to the latter part of the process; it was a question whether that should remain unchanged. He was not sufficiently experienced in that regard, nor had he watched the work of his assistants enough to be able to give an opinion, and as to whether it would now be best to fix any time, or to put in a time certainly safe, say eight hours or four hours, he was uncertain.

Mr. Farrington said that it seemed absolutely necessary that some such time should be adopted, but in extracting with ether the fineness of the sample should also be taken into consideration.

Mr. Huston said that in his extractions, except in one or two cases which would be considered entirely outside the range of ordinary work, fully 90 per cent of the extract was yielded in the first twenty-four hours, and in many cases much more than 90 per cent. He believed that the remaining extract was not a real fat. Of course, in the quantity he used, 2 grams, it was very small; but it seemed to have none of the properties of the real fat. The scheme which he believed was first described by Mr. Scovell, of leaving the extractor stoppered over night and starting it again on the following morning, was certainly ample for the purpose. He was not in a position to say whether the maceration in a Soxhlet apparatus over night removed more fat. It certainly removed considerable coloring matter; but he thought that in his own work the first twenty-four hours gave all the fat.

Mr. Caldwell said that he had understood Mr. Wiley to refer to the drying of the ether extract.

Mr. Wiley said that he had referred to the time of extraction.

Mr. Caldwell said that he had read an account of the results obtained in a large number of experiments made in the Missouri Station, where some sixty or perhaps one hundred tests of ether extraction were made, the result of which showed that the extraction was complete at the end of thirteen or fifteen hours.

Mr. Atwater asked with what substances the tests mentioned were made.

Mr. Caldwell said that they were made with the three samples sent out.

Mr. Wiley moved that the recommendation made by the reporter be so amended as to direct the extraction for sixteen hours with absolute ether. Seconded.

Mr. Huston asked whether the ether was to be left in contact with the material over night.

Mr. Wiley said that could be done when a Soxhlet tube was used, but some did not use that apparatus. He thought that the direction should be simply to extract for sixteen hours.

Mr. Atwater said that it could be done without a Soxhlet tube ; it could be done with a Johnston.

The president stated the motion to be that the recommendation of the reporter be so amended as to require definitely exhaustion with anhydrous and alcohol-free ether for sixteen hours, instead of "until extraction is found by test to be complete."

Mr. Patterson said that stopping over night had been spoken of, and he wished to know whether a continuous extraction for the time specified would be prohibited.

The president said that it would not.

The amendment was agreed to, and on motion, the method for determining ether extract, as amended, was adopted.

Mr. Caldwell said that under the head of "Crude Protein" (page 226), he recommended that all after the word "protein," occurring in the second line of the paragraph, be stricken out as unnecessary. He believed that the matter of the standard was to be provided for in the report which was to come before the association.

The recommendation was adopted.

Mr. Anderson asked whether any time was fixed for the drying after extraction with ether; the direction was to dry to constant weight.

The president said that no time had been fixed.

On motion, the method for determination of crude protein, as amended, was adopted.

Mr. Caldwell moved that the method for determining albuminoid nitrogen remain the same as it was last year (pages 226, 227). Seconded.

Mr. Patterson asked whether there was any objection to drying the copper residue before digesting with the Kjeldahl process. When it was put in wet he had trouble with frothing; it was just as convenient to dry as not to dry in his work.

Mr. Caldwell said that he could see no objection; there seemed to be no possible escape of nitrogen. The direction was inserted merely as a matter of convenience.

The president suggested that the words "without drying" might be stricken out.

Mr. Caldwell moved that the amendment suggested by the president be made. The amendment was agreed to, and on motion the method for determining albuminoid nitrogen as amended was adopted.

Mr. Caldwell moved that in the method for determination of crude fiber (page 227), the second, third, and fourth paragraphs (being all that portion of the method beginning with the words, "while this boiling is going on," and ending with the name "W. P. Cutter," in parenthesis) be stricken out. Carried.

Mr. Caldwell moved that the first part of the fifth paragraph be amended so as to read as follows : *Filter, wash thoroughly with boiling water, etc.* Carried.

Mr. Caldwell moved that the words, "and also with the air blast, both tubes," in the fourth line of the first paragraph be stricken out and the words *the tube* substituted in place thereof. Carried.

Mr. Farrington asked whether there would be no mention of the air blast.

Mr. Caldwell said that the words *and the blast of air* might be put in.

Mr. Woods said that it would be a good thing to insert that.

Mr. Caldwell moved that in the sixth line of the first paragraph the words *a blast of air may serve* be substituted for the words "the blast of air serves." Carried.

Mr. Caldwell said that he had nothing further to propose on the subject of crude fiber. It was questionable whether the strength of the acid should be changed ; he did not think the association was prepared for that.

Mr. Woods inquired why it was necessary to wash with alcohol and ether in operating on a substance that had already been thoroughly extracted with ether.

Mr. Caldwell said that it greatly facilitated the drying of the substance.

Mr. Woods said that in the cases he had tried side by side he found no gain in the drying, even in a substance where he had 0.6 of a gram of crude fiber.

Mr. Caldwell moved that the words "wash then with alcohol, finally with ether," in the sixth line of the fifth paragraph, be stricken out. Seconded.

Mr. Atwater said that the motion seemed appropriate ; he did not know that any one could say with certainty that nothing would come from the further extraction, but, as Mr. Woods had said, it had been tried in their own laboratory and no further extract was obtained.

Mr. Farrington said that he thought it was very well to wash with absolute alcohol and ether, and that it would not be well to discontinue that washing until the association had some figures upon it.

Mr. McDonnell said that the washing with alcohol seemed desirable ; in some cases it would remove some of the coloring matter which was still present. He did not think that the washing with ether was of advantage ; it certainly was not so far as drying was concerned.

Mr. Woods said that he did not know but that something would be extracted in some cases. In the case of such a coarse fodder as hay nothing was extracted by the alcohol after extraction by ether.

Mr. Anderson said that he had lately been working with green corn, and had observed that in washing with alcohol after extraction the alcohol was in every case colored.

Mr. Caldwell said that the policy of the association had been some-

what changed, and it was now desired to get a practical working method which would be sufficiently accurate for the purpose, although perhaps not scientifically accurate. This plan had been followed beginning with the method for moisture. The last statement seemed to make the matter rather doubtful. He agreed with Mr. Atwater that it was difficult to understand what the further extraction would be.

Mr. McDonnell said that in the cases he had referred to, where the color was extracted, no thorough extraction with ether had been made previously.

The amendment was agreed to, and on motion, the method for determining crude fiber, as amended, was adopted.

Mr. Caldwell said that the last paragraph in the method for cattle foods (page 228) was simply a request that the chemists should pursue an investigation which the larger part of the experience during the past year had certainly proved to be unprofitable. He moved that the paragraph in question be stricken out.

Mr. Huston said that he was so well pleased with the petroleum that he would be glad to have the association give further consideration to the matter. He agreed that it ought not to be included as a part of the official method for the ensuing year, but wished that the request to try it might be continued, believing that it might yield good results.

Mr. Caldwell said that several suggestions were to be made in regard to the conduct of the comparative work during the coming year, and the matter now referred to might be brought in among those. He merely wished to take it out of the official method.

The motion was carried.

Mr. Caldwell said that perhaps it would be necessary to go back to the subject of ash and strike out the word "pure," as the ash was not now pure.

The president said that unless objection was made the word might be stricken out.

Mr. Caldwell said that Mr. Woods had asked whether it was necessary to retain the paragraph next to the last one in the method. It was at most a mere matter of advice, and hardly amounted to that. He moved that the paragraph be stricken out. Carried.

Mr. Caldwell said that it remained to consider suggestions for comparative work in addition to comparing the official method. He would first suggest a very much more thorough sampling of the material before it should be sent out by the reporter to be tested. He moved that for the purpose of sampling, the whole mass of ground substance be put in a square box, not to be more than two-thirds filled, and which should be provided with blades of wood stretched from side to side across a portion of the area, the box to be caused to revolve for a number of hours daily, in order to ascertain whether the discrepancies observed are due to differences in analyses or to want of thorough mixture. Carried.

Mr. Caldwell said that his next motion, made upon the suggestion of Mr. Wiley, was that the extraction by anhydrous ether of the air-dried substances as sent out be made one of the requirements in the experimental work of the ensuing year. Seconded.

Mr. Burney said that Mr. Huston had stated in his paper read this morning that he had taken absolute ether, added to it the amount of alcohol contained in Squibb's ether, and had then extracted the feeding stuff with that ether, and had found an increase in the amount of extracted matter. He would ask Mr. Huston whether he had examined that extracted matter for the purpose of determining whether it was organic or inorganic; and, if so, with what results?

Mr. Huston replied that no further examination of the material was made. He considered that in everything except oil meal the quantities were too small to afford good results, and he was nearly out of material, having but three or four grams left. He determined no ash in those.

The president stated that the requirement under consideration was not to be understood as a part of the official method, but as one to be observed in testing the samples sent out during the year.

The motion was carried.

Mr. Caldwell moved that the purification of the ether extract by causing it to pass through animal charcoal, as suggested by Mr. Patterson, be tested, and said that he should like to see that suggestion applied to both extracts, that of the dried substance and that of the substance taken in its natural condition. The chemists might not be able to do so much, but it was offered as something to be done by those who had sufficient time. Carried.

Mr. Caldwell said that he had no further suggestions to make in regard to changes in methods of working. He would like to say something in reference to a somewhat different manner of getting the work done, if that would now be considered in order.

The president said that the matter was in order.

Mr. Caldwell said that, as stated in his report, it was evident that many of the chemists had but little time to spare for the experimental work, and it seemed that some of the work which had been done in that line was hardly worth doing. He thought that it might be well to confine the work to that constituent which had given the most trouble, namely, the ether extract. The samples should be sent out as early as possible, and only to chemists interested in the subject, and who would put experienced men upon the work. In this regard he had undergone a change of heart. Last year he had stated that the work might be useful as affording good practice for the younger analysts in the experiment stations, but now he did not consider this to be the purpose of the work of the association. What the association wanted was a method known to be, in accustomed hands, reliable, of which it could be said to the young men as they came in, This method is reliable, and

you will have to get good results by it. He would suggest that only the chemists of stations more particularly interested be asked to undertake the work, for if ten chemists could be given one line of work and ten others another line, the results would perhaps be better; and the reporter should confine his requirements for the experimental work, and even for the other work at first, to one subject, that of the ether extract on the carefully sampled portion. The results should be sent in not later than, say, January 1, giving the reporter an opportunity to put them in order, see how they came out, and then request a further examination if they did not come out well, showing that the trouble was in the sampling, or that some of the work had been done by inexperienced chemists. At any rate, the work on cattle food for the year, both by the official method and upon the new matters suggested, should be confined to a smaller number of chemists, and those undertaking it should be requested to put it in the hands of those only who were experienced in fodder analysis, limiting the investigation at first to the ether extract, which was the most troublesome constituent, and leaving it optional with the chemist to do the rest of the work. He threw this out as a mere suggestion, and would like to see whether it met with the approval of the association.

The president said that a vote could be taken upon the suggestion to the reporter; it would have to be put in the form of a motion.

Mr. Stubbs moved that the action suggested by Mr. Caldwell be recommended to the reporter for the coming year. Carried.

Mr. Houston said that in the preparation of the sample the substance was directed to be ground until all of it would pass through a sieve with thirty-six meshes to the linear inch. He believed that one of the chief sources of difference in cattle food analyses was to be found in the fact that so-called thirty-six-mesh sieves varied greatly, there being no standard size for the wire. The sieve specified in the method for phosphoric acid was definitely described; the cross section for the space through which the material should pass was stated; but "thirty-five-mesh sieve" or "thirty-six-mesh sieve" could not be definitely understood, the meaning depending upon the freak of the gauze maker. He had a so-called twenty-three-mesh sieve which was finer than the thirty-six-mesh sieve.

Mr. Farrington said that the matter of the sieve was very important and he would move that the description of the sieve be made to apply to the diameter of the hole, expressed in millimeters.

Mr. Caldwell said that all the samples sent out were put through the same sieve, and it was stated on the blanks that no further change was necessary. He would correct the matter in the report, and it would not be necessary to put the question on Mr. Farrington's proposed motion. The diameter of the orifice had not been stated; it was 1 millimeter, the size of hole adopted by the experiment stations in Germany as practical after carefully considering the matter at their meeting.

Mr. McDonnell asked whether the hole decided upon by the German experiment station was a round one.

Mr. Caldwell said that he did not remember positively, but thought that it was.

Mr. Wiley said that it was a matter of great difference whether the hole was round or square, and he thought it important that the association should adopt a sieve having circular holes 1 millimeter in diameter.

Mr. Caldwell said that he would so prescribe.

Mr. Farrington offered the following resolution :

Resolved, That in the opinion of this association it is desirable to publish with the results expressing the percentage of dry matter in feeding stuffs a description of the process by which such results are obtained, or a reference that will give such description.

In support of the resolution he said that although it was known what to expect in making an estimation of dry matter in feeding stuffs, the chemists might be better able to form their opinions if they knew how the results reported were obtained in each case. Not every analysis referred to the official methods, and nothing was said as to how the dry matter was obtained, which it was important to know.

The resolution was adopted.

Mr. Cooke said that one matter which had come up in times past, and had several times been spoken of in the meetings of the association by Mr. Jenkins, had not yet, so far as he knew, been acted on by any of the reporters. He referred to the method of stating average results. The reporters brought in the figures of the different chemists and gave the arithmetical average of all those figures, thus giving as much weight to a wide result as to one very nearly correct. The final computations were almost always made by clerks who could just as well go into a longer calculation that would give figures representing a probable mean and the probably correct result. The method of least squares would give the correct result, but the mere arithmetical average would not.

In regard to the determination of moisture in cattle foods, as the samples were now sent out it was hardly possible to compare the results obtained by the analysts ; this could be done if the samples were forwarded in glass, sealed, as were the samples sent out for determination of phosphoric acid and nitrogen, and then the results on ether extract could be taken for the crude fodder directly from the sample without, as was now the custom, transferring to dry matter, to which errors made in moisture are carried, making the results on the ether extract or the crude fiber appear wider on paper than they are in reality. He thought that if the samples could be sent out in such a way that they would not lose or gain in moisture the results would be brought more closely together, the comparison being that of figures obtained on the original substance instead of on dry matter.

Mr. Caldwell said that the idea advanced was a very good one. He moved that the reporter on cattle foods be requested to send out the samples in sealed glass vessels. Carried.

Mr. Atwater presented the following report on behalf of the committee appointed at the previous annual meeting, consisting of Messrs. Atwater, Caldwell, Jenkins, Jordan, and Wiley:

REPORT OF COMMITTEE ON WAYS AND MEANS FOR SECURING MORE THOROUGH CHEMICAL STUDY OF FOODS AND FEEDING STUFFS.

At the meeting of the Association of Official Agricultural Chemists at Washington, September 10-12, 1889, it was voted "that a committee be appointed to consider and report upon ways and means for securing more thorough chemical study of foods and feeding stuffs, with the purpose of obtaining such information as will aid in the improvement of methods of analysis and in the more satisfactory estimation of nutritive values." The committee respectfully report as follows:

The object sought in the appointment of this committee is more fully expressed in the discussion at the meeting, including especially that which accompanied the resolution referred to.

This evinced a very general feeling that our present methods of analysis of foods and feeding stuffs are unsatisfactory. It was urged by a number of the members that the common grouping of proximate ingredients does not correspond accurately enough with either their chemical or their physiological relations; that the current methods of determination, in the hands of different analysts, give varying results; and that even if uniform results were obtained, they would not show accurately the nutritive values which it is the object of analyses to learn. It was still further urged that the development of the experiment station system and the great increase in the amount and importance of the analytical work done emphasized the demand at the same time that it improved the opportunity for improvement, and that this improvement must be sought in abstract and thorough chemical study of the substances we are dealing with.

The urgent need of perfecting our analytical methods was also insisted upon by the committee on analysis of cattle foods, and was enforced by their report of analyses made of the same material by different experiment stations. The amounts of ether extract in the same sample of hay reported by sixteen stations ranged from 2.66 to 7.10 per cent, reckoned upon dry substance. The average was 4.78, and the mean 4.88 per cent. The difference between the highest and lowest per cent was 4.44, and this difference expressed in per cent of the average of all the results was 96.79. The differences in other ingredients were smaller, but in the crude protein, of which the average was 12.63, the highest per cent reported differed from the lowest by 3.06, which was 24.23 per cent of the average.*

The ideas thus expressed at the meeting are current among agricultural chemists in this country and in Europe. The feeling is becoming more and more general that a reform in our methods of analysis is needed, and that this must be based upon the more thorough study of the materials to be analyzed. One phase is summarized in the words of two members of the association at the meeting referred to. One remarked that the "analyses must be governed by the chemical nature and structure of the bodies dealt with; and a thorough chemical knowledge of the proximate ingredients of our animal and vegetable products is a crying need." The other, in urging the importance of more careful investigation in this direction, said: "The key note to the future success of the work of the experiment station and of the analytical chemists has been struck in calling attention to the absolute necessity of sooner or later getting underneath what lies upon the surface."

The importance of this matter has been recognized by the Department of Agriculture. The report of the Director of the Office of Experiment Stations, which makes a part of the report of the Secretary of Agriculture for 1889, contains the following:

* See, however, statements by Mr. W. W. Cooke, of the Vermont experiment station, page 128.

"A great deal of experimenting has been done and is now in progress to discover the nutritive values of food materials, the laws of nutrition, and their proper application. Experimental science has advanced to the stage in which more thorough inquiry into the fundamental principles of these subjects is necessary. Many analyses of feeding stuffs are being made by the stations, and standards for rations for domestic animals have been proposed and are widely used; but the results of actual feeding tests do not always agree with those obtained by analysis and recommended in feeding standards. While analyses of feeding stuffs by the methods now current have been and are of the greatest service, especially when combined with results of experiments upon digestibility and other physiological research, it is universally recognized by agricultural chemists that chemical analysis alone gives a very inadequate idea of the true nutritive value of a feeding stuff. The late advances in physiological chemistry all point to the possibility of getting such knowledge as will show feeding values with reasonable accuracy. One thing now especially needed is a thorough study of the chemistry of vegetable and animal products used for food. For this purpose it is essential to make more accurate separations of the proximate compounds and investigate them individually with reference to their molecular constitution and their potential energy. This means the most accurate, profound, and detailed research in analytical, organic, and physiological chemistry. It will require much labor and that of the highest scientific order, but neither its magnitude, its difficulty, nor its cost should prevent its being undertaken and carried to successful issue. The interests of the agriculture of the country as well as of scientific advancement are too great to permit its neglect."

On page 248 of vol. 1 of the Experiment Station Record the same idea is expressed in the following language:

"It is important, indeed indispensable, that we have more thorough knowledge of the chemical constitution of the materials used for feeding stuffs. The studies need to be prosecuted in such ways as to determine, for each species of plants, and for the different parts of the same plant, the kinds of proximate ingredients, the amount of each ingredient, and its molecular constitution, its digestibility, and its fuel value as measured by its potential energy."

We make analyses of foods and feeding stuffs to determine their nutritive values. To plan proper methods of analysis, we have then to consider on the one hand the composition, solubilities, and other chemical properties of the proximate ingredients, and on the other their physiological characters, their digestibility, and their functions in nutrition.

At present we determine, or assume that we determine, one group, which we call protein, by multiplying the total nitrogen by 6.25; a second, which we call fats or crude fats, by extracting with ether; a third, which we call fiber or crude fiber, by extracting with dilute acid and alkali; a fourth, which we call ash, by incineration, and a fifth, which we call nitrogen-free extract, by subtracting the sum of the first four from the total water-free substance, which last we get by subtracting from the whole weight the weight of water as determined by more or less accurate dryings.

We know that the proximate ingredients which we thus roughly class as belonging to each of the four groups, protein, fats, nitrogen-free extract, and fiber, differ in different plants, and in different parts and in different periods of growth of the same plant, in respect to number, chemical properties, and nutritive values; that there are compounds even in our common foods and feeding stuffs which do not properly belong in the groups in which we class them; that the figure found for each group in any given plant or part of a plant (and the same is true, although in less degree, in animal substances) by our current methods of analysis is not entirely correct even with the best possible work in the laboratory; that in the hands of different manipulators the results are widely divergent; and that if our analytical results were perfectly accurate in themselves, they would not even then give us an exact measure of what we really want to learn, namely, the nutritive values of the materials analyzed. In short, we know perfectly well that our present methods of analysis are chemically and

physiologically imperfect. The results do not agree with practical experience, and we do not even agree among ourselves in the analyses we make.

This is of course a one-sided statement. In a sense it is exaggerated. A layman might infer from it that chemical analysis is an entirely unreliable means of estimating nutritive values. That would be unwarranted. The truth is, simply, that we are in the earlier stage of the development of our science, and that our methods are still crude. They have done and are doing service that is invaluable, but the time has come when greater accuracy is needed.

We represent the science of the country as related to its most important material interest. It is our office to pronounce upon the character of the materials we study and to advise people of their values and proper use. What are we going to do about it?

Evidently the first thing is to consider what we are dealing with. What, then, are the principal proximate ingredients of our more common feeding stuffs and food materials, and what are their properties as viewed from our standpoint?

In vegetable materials, by our present methods, we determine, or assume that we determine, one group, which we call protein, by multiplying the total nitrogen by 6.25; a second, which we call fats or crude fats, by extracting with ether; a third, which we call fiber or crude fiber, by extracting with dilute acid and alkali; a fourth, which we call ash, by incineration; and a fifth, which we call carbohydrates or nitrogen-free extract, by subtracting the sum of the first four from the total water-free substance, which last we get by subtracting from the whole weight the weight of water, as determined by more or less accurate dryings. In animal products used for food we have no crude fiber and the quantities of carbohydrates are generally so small, except in milk and its products, that we neglect them.

Protein.—This term is applied to a large number of materials which differ very widely in chemical and physiological properties. Even the terminology is in great confusion. We may here designate them proteids and non-proteids.

The proteids include the albuminoids, which are abundant in both vegetable and animal materials, and the so-called gelatinoids, which are especially characteristic of the connective tissues of animals. The vegetable albuminoids are very imperfectly understood. They are numerous and difficult of separation and are more or less readily transformed into one another. The per cent of nitrogen, which should be 16 to make the ordinary factor 6.25 correct, varies considerably, not only in different classes of albuminoids, but in those of the same class from different species of plants, and if the results obtained by different investigators are to be relied on, in those of the same class from different plants of the same species. With the animal albuminoids that chiefly concern us the case is somewhat simpler. They appear to be less in number, those which we group together are perhaps more nearly alike in chemical constitution, and they change less with the growth and development of the organism and in the keeping and handling in the laboratory. Generally speaking the nitrogen factor, 6.25, is not far out of the way for them. Still we must learn much from organic chemistry and histology before we can know how to separate and determine them and judge of their nutritive values with accuracy. The same is true of the gelatinoids, of which really but little is definitely known.

The non-proteid nitrogenous compounds include those to which the term amides is often applied, and which occur chiefly in plants; those which are frequently grouped with kreatin and are more characteristic of animal substances; and others, such as the lecithins, alkaloids, and nitrogenous glucosides, which occur to greater or less extent in either vegetable or animal materials or in both. They are widely divergent in chemical composition, and while some of them have a high nutritive value, others, including many with the highest percentages of nitrogen, neither form tissue nor yield energy in the body. At present there is no satisfactory way of determining them. Even the methods for "non-albuminoid" nitrogen in vegetable substances do not stand the test of critical experience. All of them demand further investigation.

It is perfectly clear then that the practice of determining the total nitrogen, multiplying it by 6.25, calling the product protein, and using it as a measure of the nutritive value of the nitrogenous ingredients, is a very rough and inaccurate way of doing things.

Fats—Ether extract.—The case with the so-called crude fat is no better. In such animal substances as muscular or connective tissue, milk and products from it, the ether extract, if obtained by proper manipulation, contains the fatty bodies and little else. But the compounds we extract from vegetable products and denominate as crude fat, ether extract, or for short, fats, are very diverse, nor are we at all sure what proportion of them we extract by our ordinary methods. We have to deal not only with the true fats, *i. e.*, glycerides of the fatty acids, and the fatty acids themselves which may be properly classed with the fats in estimating nutritive values, but also with a great variety of other compounds of widely differing constitution, and of whose functions and value in nutrition but little is known. Among them are vegetable acids other than the fatty acids, substituted glycerides including the various modifications of lecithin, waxes, alkaloids, cholesterin, hydrocarbons, and chlorophylls. Of these the lecithins appear to have a special value in nutrition, while some of the alkaloids are poisons.

If the substance to be analyzed is finely ground, free from water, and in otherwise normal condition and the cell structure allows easy extraction, we may in general expect that absolute ether, properly applied, will take out the whole of the true fats and fatty acids, and more or less of the other acids, lecithins, wax, chlorophyll, cholesterin, alkaloids, and solid hydrocarbons, and that more or less of the compounds other than true fats and fatty acids will remain undissolved. If the ether contains alcohol the extract may be expected to contain more of the other compounds. If water is present the extract may be, that is to say, in numerous observations it has been, apparently larger; but we do not know yet exactly what compounds are affected by the presence of alcohol or water, or to what extent.

It is well established that when vegetable products are heated in air as is done in drying, less ether extract is obtained. The theory is that fats are oxidized and rendered insoluble in ether. But what the specific compounds are and what chemical changes they undergo, we do not know. The amount of decrease in solubility is in some cases far greater than would be easily explained by the oxidation of linoleic acid. Are not other compounds affected, and do they not undergo more or less change on standing or in drying at ordinary temperatures? Such is familiarly the case with drying oils. May it not be so in the substances we have to analyze? And do not changes in the cell walls and incrusting materials, in standing and heating, have much to do in preventing substances of themselves soluble from being dissolved?

Incidentally these considerations suggest numerous queries. In drying in hydrogen are we always sure that the hydrogen we use is entirely free from oxygen? How much difference is there between the extract by absolute ether and by the ordinary ether we buy for pure ether? What of the effect of fineness of grinding and time of extraction upon the amount and composition of the extract? What difference does it make whether we use the fresh substance or that which has been standing in the laboratory or elsewhere for a long time?

At the last meeting of this association a member (Professor Scovell) reported a case in which he had obtained with absolute ether from hay 3.03 per cent of extract. By letting the extracted material stand one night with absolute ether, and extracting again the next morning, a larger result was obtained. With Squibb's ether, supposed to be anhydrous, but not alcohol-free, a much larger extract was obtained. Apparently the chlorophyll was more fully extracted by the use of Squibb's ether.

In inorganic analysis we have constantly to do with cases in which the solubility of a compound in a given reagent is materially affected by other compounds. Have we sufficiently considered the importance of analogous reactions in organic analysis?

For instance, some of the alkaloids are soluble in ether. Some are themselves insoluble in ether, but when associated with other compounds in vegetable or animal substances are extracted by ether in the ordinary process of fat determination. It is very likely the fats or fatty acids decide the solution; in other words, in the presence of neutral fats or fatty acids, alkaloids may be dissolved by ether which in their absence would not be dissolved.

Among the substances which cause trouble in fat determinations are the lecithins, which are partially soluble in ether. In the ordinary bean, of the total crude ether extract obtained by treating with alcohol, evaporating and treating the residue with ether, about 30 per cent has been found by Mr. W. Maxwell to consist of lecithins and 6 per cent cholesterin and 5 per cent solid hydrocarbons, which makes over 40 per cent of the whole crude extract to be other material than neutral fats. The following figures, which were kindly supplied by Mr. Maxwell, illustrate the quantities of materials other than fats which have been found in the seeds of the plants named. They help to understand why the amounts of ether extract obtained by different analysts are so variable.

Proportions of lecithins, cholesterin, etc., in one hundred parts of "crude fat" (ether and alcohol-ether extract) of seeds.

	Lecithins.	Cholesterin.	Hydrocarbons.	Fats and undetermined.
Bean*	29.5	6.0	5.0	59.5
Pea	† 35.1	† 3.0	(§)	61.9
Horse bean	† 47.8	† 2.0	(§)	50.2
Vetch	† 28.0	† 4.0	(§)	68.0
Cotton (upland)	2.3	(§)	(§)	97.7
Maize	3.3	(§)	(§)	96.7

*Average of analyses by W. Maxwell.

†Average of results by Maxwell and by Jacobsen. Later results by Maxwell, not yet published, indicate that these figures are too small.

‡Average of results by Maxwell.

§Undetermined. Analyses by Wiley and Maxwell.

Among the numerous illustrations of the value of special studies in these directions may be cited the investigations by Stellwag,* who has studied the extracts obtained with ether and with "*benzin*" (the lighter hydrocarbons of petroleum?) from hay, seeds of cereals and legumes, bran, oil cakes, etc. He finds in the ether extract from hay about 23.7 per cent of neutral fats, 37.3 per cent of free fatty acids, and only traces of lecithins. In the grain of barley and oats and bran of wheat and rye the free fatty acids ranged from 14 to 35.4 per cent and the lecithin from 2.1 to 4.3 per cent. In the seeds of pea, vetch, and horse bean the percentages of lecithin were from 21.3 to 27.4; in cotton-seed cake the lecithin made 4.4 and in potatoes 3.1 per cent of the total ether extract. In the "*benzin*" extract the percentages of lecithin were in general much smaller. He considers "petroleum ether" of low boiling point a more proper solvent for fats than ether, because it dissolves less of the materials not fat, such as wax (bees'-wax) and numerous organic and mineral acids.

But perhaps the chief outcome of this, as of other valuable investigations, is to bring into clearer light the need of further and more detailed study of the subject.

It may be that such means as the case of animal charcoal for the purification of ether extract from non-fatty substances in the manner lately suggested by one of our fellow chemists† may prove useful. But it is clear that what we need to know first is the nature of the substances with which we have to do.

*Die Zusammensetzung der Futtermittelfette. Landw. Vers. Stationen, 37, 1890, 135.

†H. J. Patterson. Am. Chem. Jour., 12, 261.

The nutritive values of the materials which are more properly grouped as fats, *i.e.*, the glycerides of the fatty acids and the fatty acids themselves, are pretty well understood, though further investigation of the molecular constitution of some and of the potential energy of all is needed. The fact that lecithins seem to be readily assimilated by animals, that they are important constituents of brain and nerve tissues, and that on decomposition they yield fatty acids with large potential energy, all indicate for them a high nutritive value. The waxes are still imperfectly understood, but from what is known of their constitution it would seem that in so far as they are digestible their nutritive values must approximate those of the fats. Of the glucosides our present knowledge enables us to say but little. The same is true of the chlorophylls, cholesterin, the hydrocarbons, and the alkaloids.

According to the present outlook, therefore, it seems probable that although the waxes and perhaps the lecithins may be classed with the fats in estimations of nutritive values, a separate classification of some or all of the others will be necessary; and it is clear that a more definite knowledge of the chemical constitution of all the materials other than the neutral fats and fatty acids is indispensable to any correct estimate of their values for nutriment.

Carbohydrates.—The need of better understanding of these is hardly less pressing than is the case with the fats or protein compounds.

The ordinary classification of carbohydrates as glucoses, saccharoses, and amyloses will hardly suffice for the purposes of analysis or for the determination of nutritive values. For analysis a more desirable grouping will probably be based upon solubilities. We may perhaps distinguish between (1) those soluble in water, (2) those which are rendered soluble by digestive (diastatic) ferments, (3) those which are not so dissolved, but are dissolved by dilute acid or alkali, and (4) those which are not dissolved by either of the agencies named.

The first class will very likely include the glucoses, saccharoses, and, of the amyloses, the dextrines, galactans, dextrans, laevulans, and perhaps inulin, and others. The second will naturally consist of the starches and allied compounds, including (*a*) amorphous starch, which when suspended in water at 45° or thereabout is acted upon by ferments; (*b*) granulose starch, acted upon by ferments after gelatinizing by treatment with water at 100°; (*c*) cellulose starch, acted upon by ferments after gelatinizing by treatment with water or steam under pressure of two or three atmospheres. The third will include paragalactans and the substance which yields xylose on treating with dilute alkali (gums) and allied bodies. The fourth will include the celluloses and allied compounds.*

The place or places into which investigation will bring the pectins, mucilages, and other less understood compounds it is, of course, impossible to predict. For that matter this tentative grouping is suggested simply to illustrate what needs to be done.

It is essential to study carefully the carbohydrates which occur in different plants, in different parts of plants, and at different periods of growth and to learn their behavior with solvents and their methods of separation. It is also important to learn more about their digestibility and the ways in which they are utilized in the body. Much of the information must be gained by the methods of vegetable physiology and histology rather than by purely chemical methods.

Of the nutritive values of some of the carbohydrates, especially those which are soluble in water or are rendered soluble by the diastatic ferments, we have some definite knowledge. For instance, the sugars may be reckoned as completely digestible and the potential energy of a number of them has already been determined and others are being studied. The problem here is comparatively simple. With those that are not dissolved by either water or the digestive ferments the case is somewhat

* The classification here suggested is for the most part as has been proposed by Mr. W. Maxwell, but not yet published in detail.

more complicated, but it is to be hoped that research of the kinds now being carried on by several chemists in this country and in Europe will bring before many years much of the definite information which is needed.

As regards the celluloses we are still in doubt. The questions as to how they are digested by the agency of bacteria or of enzymes; what are the products of their fermentation, *i. e.*, how much is marsh gas, how much consists of acids of little or no nutritive value, and how much of substances akin to glucoses; to what extent those products are assimilated, their potential energy made available, and their service in forming fat or protecting protein from consumption is effective—all these problems still await satisfactory solution. Until they are solved the nutritive values of the celluloses must remain in doubt. It seems probable, however, that our present method of grouping these compounds will be followed for some time to come.

It is to be noted, with regard to compounds belonging to each of the above classes, that in many instances, especially with vegetable materials, the solubility of the ingredients in laboratory reagents, their digestibility in laboratory experiments and in the animal's body, and their nutritive effect are dependent upon the ways in which they are held in the vegetable tissues, *e. g.*, the nature of the cell walls or incrusting substances. Of these things ordinary chemical analysis tells us little or nothing, and we must look to the vegetable histologist to find out about them for us. Meanwhile in ignoring them we commit more or less serious error.

In providing for a proper classification of proximate compounds it will be necessary to study some of the less known substances for which we have as yet no fixed place, such as, for instance, the alkaloids and pigments. The effect of mechanical condition upon solubility and nutritive values, as in the case of cellulose, which has been found to be more digestible in young than in older plants, and likewise more digestible in plants grown in rich than in those grown on poorer soil, demands investigation.

The results of such research as has been above indicated will doubtless lead not only to changes in the general groupings and methods of analysis, but also to special groupings and methods of analysis for different classes of vegetable and animal foods and feeding stuffs.

It is hardly to be expected, for instance, that we shall always hold to the same grouping of compounds for grasses, cereal grains, leguminous plants and their seeds, root crops, milk, and meats. It is more probable that groupings for different classes of materials, with corresponding methods of analysis and of estimating the nutritive values, will prove both necessary and feasible.

To recapitulate, briefly: We have a partial, but only a partial, knowledge of the proximate ingredients of the vegetable and animal substances used as food for man and as feeding stuffs for domestic animals. We do not know exactly what ones are contained and in what proportions in different plants, in different parts of the same plant, and at different periods of development of the plant. We lack that information as to their chemical behavior which is needed to devise plans for their correct separation and determination, nor is our knowledge any more nearly adequate for estimating their digestibility and their nutritive values. The same is true, though to a less degree, of the compounds with which we have to do in animal substances. The classification which we are now using is crude and inaccurate from the standpoint of analytical, organic, and physiological chemistry. The results of our analyses are variable and at best inaccurate, and even if they were entirely accurate the estimates of nutritive values based upon them would often be very far from correct. The only way to get the information which is requisite for rational groupings of compounds, accurate analyses, and correct estimates of nutritive values is by the most thorough, painstaking research in analytical, organic, physical, and physiological chemistry.

WHAT IS TO BE DONE ?

The proper reform of our methods will evidently come as fast as does the chemical and physiological knowledge which must serve as the basis for it, and no faster. This means that the most abstract and profound study is necessary. Fortunately such study is engaging more and more the attention of chemists and vegetable physiologists.

From the chemical standpoint we need: First, such studies as will bring definite knowledge of the kinds and amounts of proximate compounds contained in each substance to be analyzed; that is to say, (1) in different plants, as grasses, grains, cereals, legumes, tubers, roots, etc.; (2) different parts of the same plant, as the stalk and seed of maize and wheat and the different parts of the wheat grain; (3) in the same plant at different periods of growth; (4) in animal substances. Second, studies of each compound regarding its behavior with reagents, *i. e.*, solubility, etc., its elementary composition, its molecular constitution; the changes it undergoes by the action of ferments; its digestibility; and its potential energy. Third, classifications of the compounds based upon the properties named. Fourth, improved methods for separation and estimation based upon the same properties. Fifth, as the outcome of all this, more correct methods of estimating the nutritive values.

This all means a vast amount of research, and that of the highest order. Its practical usefulness is as clear to the student as that of any experimental inquiry in which our Experiment Stations and other institutions for research are engaged.

But it is not easy to persuade the public at large of their immediate importance. It is not easy for Experiment Stations to secure the high order of talent and training that is needed, and devote the requisite labor to such inquiry.

Nevertheless the Stations can do something, and each investigation of value they make will help to the making of more. Organic and physiological chemists who have the opportunity and taste for research will find here a promising field, one which has the threefold advantage of newness, promise of results of the highest theoretical value, and assurance of practical usefulness.

Investigations in these lines have been already undertaken by the Department of Agriculture, and coöperation between it and the Experiment Stations and other institutions of research can not fail to be useful in the highest degree.

What is needed first of all, however, is the compilation of what is best known in these lines. When all that has been done is well put together we shall doubtless find that what has already accumulated is much greater and more helpful than we at present realize. The necessity of such compilation is all the more urgent when we consider its fundamental importance for the planning of research.

The work of the Association of Official Agricultural Chemists in developing and improving the methods of analyses has been of the very greatest value. The methods which we now follow are largely of the rule-of-thumb order, but the rule of thumb is better than no rule at all. That we are all working by the same methods, and those the best that in the present condition of our knowledge we can devise by united effort, is far better than that we should work by methods differing from one another, and each no better, and in general not so good as the common method which we follow. And one of the most valuable results of the efforts of the association has been to bring into clear light, to emphasize, and in a measure explain, the need of improvement of methods.

It is one thing to be drifting helplessly in an unknown sea, and quite another to know exactly where we are and in what direction our port lies. We are finding out a little as to our situation, our bearings and distances. We want a map which will show us just what exploration has discovered; then by united effort we can gradually and truly learn about the currents, the coasts, the reefs and where the harbors are.

The information as to what has been learned can be best collated by the coöperation of specialists. This could be accomplished through the Department of Agriculture. We have a considerable number of men in the United States who have devoted large amounts of time to the study of particular branches of the general subject. Some of them are connected with the Experiment Stations and Department of Agriculture; others are professors and instructors in colleges. For branches of the subject in which there are no specialists on this side of the Atlantic it would be well if the services of leading European specialists could be secured.

For the prosecution of the necessary investigations coöperation of a large number of specialists will of course be requisite. We may confidently expect that Experiment Stations will be able to devote more and more labor to this higher research. Its scientific value is such that chemists in our colleges and universities ought to be led to join in it. Is it too much to suggest that international coöperation might be secured? One essential is the means for paying the expenses of the work. For this a small amount of money would do a great deal. There are many investigators in the country, both those who have already acquired reputation and influence and those who are ambitious to secure them, who would gladly give their time and thought to investigations in their several specialties, the combined results of which would bring the needed information, if they could only have the means for defraying the expense. A hundred dollars here, two hundred there, and five hundred in another place, would bring the results for which thousands would be necessary if the work was to be done by men especially employed and paid.

In what the Smithsonian has done in times past in promoting research by small amounts of money we have an illustration of what might be accomplished here. The result would be useful in several ways; it would encourage research, develop talent, and improve the intellectual tone of the institutions where such work was being done; its influence upon the development of science in the country would be excellent, and the practical values of the outcome would many times exceed the cost.

Might not the association make good use of the influence which it has gained by endeavoring to secure from the institutions with which it is connected and from the Government, through the Department of Agriculture, the means which would contribute to so desirable a result?

Mr. Myers moved that the report be accepted as a report of progress, that the committee be authorized to take such steps in coöperation with the reporters on foods and feeding stuffs as would, in their judgment tend to promote the objects desired, and that the committee be continued. Carried.

Mr. Huston read the following paper:

*NOTES ON THE OCCURRENCE AND QUANTITATIVE ESTIMATION OF THE
PENTAGLUCOSES IN FEEDING STUFFS.*

By W. E. STONE.

It is desired to call the attention of those chemists interested in the analysis and valuation of foods to the results of some study of the pentaglucooses as food constituents. By the term pentaglucooses we understand a group of sugar-like bodies with the general formula $C_5H_{10}O_5$, belonging therefore to a distinctly different series of derivatives from the true glucoses or the true carbohydrates. The bodies do not occur free in nature as do the true glucoses, but my observations go to show that the peculiar class of gum-like bodies from which they are derived are of common and abundant occurrence in most vegetable products. These pentaglucooses are two in

number so far as is yet known, viz, *arabinose* and *xylose*. *Arabinose* may be prepared by the action of dilute acids upon certain gums, such as gum arabic, gum tragacanth, cherry gum, peach gum, etc. More than this, if we extract different forms of vegetable tissue with weak alkalis we have in solution gum-like substances which are abundantly precipitated by alcohol, and which by hydration with dilute acids also give, in some cases, *arabinose* and in others *xylose*. In this way these pentaglucooses have been actually isolated from sawdust, straw, bran, brewers' grain, the pulp of sugar beets, etc. Concerning the nature of these gums which give rise to the pentaglucooses we know little. The name *gum* is perhaps ill fitting, but is retained here for convenience. Whether the gums, such as gum arabic and cherry gum, produced under abnormal conditions are similar to those materials extracted from plant tissues by alkalis is questionable, but they at least seem to bear the same relation to the pentaglucooses. This relation we may compare in a very general way to that between starch and glucose, i. e., the hydrating effect of acids converts the one into the other.

My earlier observations have established that the pentaglucooses differ from the true glucoses by one characteristic reaction. They yield, when slowly distilled with strong acids, large quantities of furfural. No member of the true glucoses or any of the bodies from which they are derived will respond to this reaction. *Arabinose* and *xylose* yield, on the other hand, about 50 per cent of their weight in furfural. Not only this, but all of those substances from which the pentaglucooses have been prepared also yield corresponding quantities of furfural. Hence this becomes a reaction for the recognition in crude vegetable products of the pentaglucooses or the bodies from which they are derived. The application of this test consists in distilling a small quantity (about 5 grams) of air-dried material with sulphuric acid of 1.254 specific gravity during several hours at 125° to 135°. The furfural formed is collected in the watery distillate, and in order to maintain the acid at a constant concentration water is allowed to drop slowly into the distilling flask at a rate corresponding to the distillation. The furfural is estimated in the distillate by concentrating the same by fractional distillation and precipitating with dilute ammonia as furfuramid, in which form it is dried and weighed. The furfuramid thus obtained stands in the relation to the pentaglucoose of 1 to 1.679, that is, the percentages given below need to be increased by nearly four-fifths in order to give us their equivalent in actual pentaglucooses.

Forty common materials, selected with the view of obtaining as great variety as possible, have been examined for the occurrence of the pentaglucooses. In the following thirty appreciable quantities were recognized.

Material.	Furfura- mid in air- dry sub- stance.	Material.	Furfura- mid in air- dry sub- stance.
	<i>Per cent.</i>		<i>Per cent.</i>
Hungarian grass.....	3.34	Corn cobs.....	8.16
Timothy hay.....	1.18	Gum arabic.....	5.46
Clover hay.....	1.55	Gum tragacanth.....	8.08
Clover ensilage.....	0.40	Cherry gum.....	8.14
Corn stover.....	2.89	Peach gum.....	4.84
Maize ensilage.....	0.91	Manure from cattle fed on maize en- silage.....	2.88
Malt sprouts.....	1.82	Manure from cattle fed on corn stover..	3.94
Brewers' grain.....	7.20	Seeds of white lupine.....	0.95
Wheat straw.....	4.16	Seeds of yellow lupine.....	1.69
Oat straw.....	2.29	Coats of orange seeds.....	1.85
Cotton-seed hulls.....	3.66	Orange peel.....	0.69
Corn bran.....	1.80	Watermelon seeds.....	2.70
Corn cob meal.....	0.59	Pulp of strawberries.....	1.95
Linseed meal.....	1.27	Beet pulp.....	3.59
Oatmeal.....	0.40		

Eight substances examined did not yield appreciable quantities of furfuramid, but still gave fine qualitative reactions for furfural.

They were, cotton-seed cake, corn meal, sweet potatoes, kernels of orange seeds, raw coffee, buckwheat, dried strawberries, and beans.

This list might be greatly extended, yet it suffices to prove the common occurrence of the pentaglucooses, respectively the bodies from which they are derived, and that, too, in considerable quantities, ranging from 1 to 12 or more per cent.

As regards the behavior of the pentaglucooses to Fehling's solution, their reducing action has been known as long as the bodies themselves, but their *quantitative* reaction had not been worked out. For *arabinose* I have determined the constants for solution of 1 per cent or less by the gravimetric method, and find that it is more strongly reducing than any sugar yet studied. Without reviewing this work in detail, it may suffice here to compare the amount of arabinose and the true sugars necessary to precipitate the copper in 1 cubic centimeter of Fehling's solution, as follows:

	Mgr.
Arabinose.....	4.532
Dextrose.....	4.753
Levulose.....	5.144
Invert sugar.....	4.941
Galactose.....	5.110
Milk sugar.....	6.757
Maltose.....	7.780

Of this list, therefore, arabinose is the most strongly reducing. The other pentaglucoose, *xylose*, has not yet been studied in this relation, but the work will soon be undertaken, and there is no reason to doubt that it also will differ from the true carbohydrates in this respect.

We see, therefore, that here is a group of common food constituents which have heretofore been classified with the carbohydrates or non-nitrogenous extract matter, but which have distinct characteristics and, it is safe to assume, special food values of their own. Let us consider the importance of their recognition as food constituents.

It is a notorious fallacy of our food analyses that under the term "non-nitrogenous extract matters" we collect a great number of different bodies of very unlike nature, although in our food valuations and digestion experiments we assume a homogeneous composition and behavior for them. This class of bodies often reaches a very high percentage of the food, so that the error is exaggerated. It appears, however, from the foregoing results that it is possible to differentiate from the others a specific class of compounds which, while they resemble carbohydrates, have undoubtedly a different digestibility and food value. For instance, in the list of materials examined it appears that these pentaglucooses or their gums induced the action of destructive processes of the silo in both maize and clover.

Again, they were found in large quantities in the manure of animals fed on at least two different rations. Yet the ordinary food analysis would leave us no ground for distinguishing between these and the true carbohydrates, like starch, glucose, etc., which we know easily yield to fermentation and digestive action. The most cursory examination shows us at once that here is a source of error in our methods of measuring food values, digestive action, etc.

Again, in their relation to analytical methods we note that here are compounds which we may easily compare with the glucoses, but which have an entirely different origin. Suppose a determination of starch to be made in any material by means of inversion and titration with Fehling's solution. Accompanying the starch we may have an indefinite quantity of the pentaglucoose gums. The same action which converts the starch into glucose also changes these gums into pentaglucooses, and the results obtained with the Fehling's solution are ascribed to starch when they may be due largely to something quite different. To suppose an extreme case, an examination of brewers' grain, which, if thoroughly fermented, contains no starch or glucose, might still give us results which could, according to present views, be only interpreted as indicating 10 or 12 per cent of starch, while actually it came from the pentaglucoose gums, which are not destroyed by fermentation.

Having pointed out thus briefly (without reference to the details of work on which

the conclusions are based, and which will be published presently) the importance of this class of food constituents, it is next desirable that some methods for their speedy and convenient recognition be developed. Such a method must rest upon their characteristic reaction of yielding furfural under certain conditions, since in most other respects they resemble closely the true carbohydrates. Such a method must also enable us to recognize these bodies in the presence of other compounds and without previous manipulation of the material.

The method has already been developed on these lines to that point where its eventual success seems assured, although it is at present far from perfect. It consists of two phases:

- (1) Conversion of the pentaglucooses or their gums into furfural.
- (2) The determination of the furfural.

The first phase has thus far been accomplished by distilling the material to be examined with strong sulphuric acid of specific gravity 1.254 at a temperature of 125° to 135°, the distilling flasks being placed in a paraffin bath and connected with a condenser for collecting the furfural and with a water reservoir for supplying the loss by distillation. The process lasts eight to twelve hours.

To determine the furfural two methods have been followed: the one already mentioned, and by which the results given were obtained; the other, since worked out, consisting in titrating the furfural containing distillate with a standard solution of phenyl-hydrazin, detecting an excess of the latter by means of its powerful reducing effect upon Fehling's solution in the cold.

This method of determining the furfural is rapid and accurate. The most difficult part of the entire process is the distillation, in which the conditions are hard to control, and yet successive determinations have been repeatedly obtained not varying more than 0.2 to 0.3 per cent from one another. The development of this method is still in hand, with good prospects of successful solution. Meanwhile this communication is submitted for the purpose of calling attention to the existence of an important and abundant class of bodies not heretofore recognized in our consideration of the composition and analysis of foods.

Mr. Huston said that Mr. Stone was very modest in regard to the second of the analytical methods which he had worked out; the process was an exceedingly short one for titrating the furfural.

Mr. Cooke said that lest the members of the association should go home with the idea that the work they had done upon the samples during the past year was not so good as that done the year before, he had figured out a few of the differences. He presented the following table:

Material analyzed.	Per cent of members agreeing within 0.50 per cent on the fat determinations.	Per cent of members agreeing within 1 per cent on fiber.
Hay	$\left. \begin{array}{l} 1889 \\ 1890 \end{array} \right\}$ 20	61
Bran middlings	$\left. \begin{array}{l} 1889 \\ 1890 \end{array} \right\}$ 70	65
Cotton-seed meal	1889 70	
Linseed meal	1890 88	

Mr. Wiley presented the following report:

NOTES ON METHODS OF SUGAR ANALYSIS.*

By H. W. WILEY.

The subject of the analysis of sugar would be appropriately introduced by a general statement concerning the difficulties which have been encountered heretofore in securing uniformity in this class of work. Briefly, I may say that these discrepancies in analytical results have been due, especially, to three causes, viz:

First, inexperience on the part of analysts; second, imperfections and variations in the instruments employed; and third, variations in the standards which have been used.

In regard to the first question it can only be said that the difficulties encountered from this source can only be removed by a more careful consideration of saccharimetric methods and a greater degree of careful practice on the part of analysts. It is reasonable to expect that the same degree of improvement which has characterized other lines of research in which the Association of Official Agricultural Chemists has been engaged will attend any efforts in this direction.

In regard to the second difficulty, viz, the use of different instruments and instruments which have been differently graduated, a less degree of progress must be expected. It is not always easy to determine in any given way what method of graduation has been followed in the standardization of any optical saccharimeter which may be in the analyst's hands. The truly scientific method of graduating an optical saccharimeter would be the use of the absolute cubic centimeter, *i. e.*, the volume occupied by 1 gram of water weighed in vacuo, at 4° temperature, and the use of absolutely pure sugar weighed in vacuo for fixing the 100° point on the scale.

In point of fact, however, different manufacturers use different methods for the graduation of their instruments. Instead of the true cubic centimeter, as described, it has been very common to use what is called the Mohr cubic centimeter, viz, taking as 100 cubic centimeters the volume occupied by 100 grams of water at a temperature of 17.5°. In the Schmidt and Haensch instruments it is stated by them that the Ventzke scale which is used by them is obtained by the solution of 26.048 grams of pure sugar in 100 cubic centimeters of water at 17.5°, and that the specific gravity of the solution is 1.10 and that its angular rotation in a 200 millimeter tube is equivalent to $(\alpha)D = 34.55$. This is the method of standardization which they give in their printed instructions to guide analysts in the use of their instruments. In a recent letter, however, received from them they inform me that the true value of the Ventzke degree is expressed by the equation $(\alpha)D = 34.68$, which is quite a different number from that given in their printed instructions, viz, 34.55.

For the daily control of an optical saccharimeter there is, perhaps, nothing superior to a first-class quartz plate, the value of which has been tested against pure sugar. The danger, however, of using a quartz plate at its marked value is so great that I need not caution the members of the association against it. The quartz plate also has different values, according to the position in which it is placed in the instrument, so that its value should be fixed once for all by comparison against a pure sugar solution. A control tube may also be used which can be made of variable length by a ratchet and scale moving over a carefully graduated vernier, using pure sugar solution for charging the tube. An optical saccharimeter should thus be carefully tested at each 5 degrees from zero to 100°, and any inaccuracy in the scale noted and allowed for in practical work.

In regard to the kind of instrument which is to be employed this must be left to

* An extensive bibliography of articles relating to sugar analysis has been prepared. On account of its great length it is here omitted, and will be published subsequently as a separate bulletin.

the preference of the analyst. There are, however, three classes of instruments which have met with general approbation, and it is earnestly suggested that the analysts connected with this association confine themselves, at present, to one of these classes. These are the Laurent instrument, the Scheibler color instrument, and the Schmidt and Haensch shadow instrument. For ordinary work the Schmidt and Haensch shadow instrument with a single scale is quite efficient; for accurate work their instrument with double compensation is to be recommended. The method of adjusting the double compensating instrument is as follows:*

"Before instrument No. 1427 can be used it is necessary to control the zero-point. After the red scale has been placed on zero the wedge corresponding to the black scale is moved until the field exhibits the same tint throughout. The black nonius should then point exactly to zero. If this is not the case the wedge is moved by means of the micrometer-screw on the left until absolute zero is obtained. The correctness of this zero is determined by repeated trials. If now, after both scales are placed at zero, one side of the field appears colored we must proceed as follows: The wedges are removed and the color of the field observed. The large wedges are removed by screwing them out as far as they will go and then simply pulling them out; then the two screws *a* and *b* are removed and the small wedges taken out.

 If now the field does not show an even tint the analyzer is moved by the two screws placed at the  side, loosening one and tightening the other correspondingly until the desired result is reached. The small wedges are now put back in the order in which they are marked, the large wedges placed in position, and the zero point corrected as before. The zero point of the instrument is now accurate, and if the divisions of the scale are correct the quartz plate should give the correct reading. If, however, an incorrect reading is obtained, the plate should be taken out and controlled by means of the red scale. If this gives the correct reading the black scale is wrong, otherwise both scales are inaccurate.

"The scales of the instruments are prepared by means of a number of normal quartz plates, whose values have been determined by several German, Austrian, and Belgian scientists and chemists. A control determination of these values is made every two years. An official examination of the quartz plates has never been made. Various chemists at times attest the accuracy of our instruments. For the last fifteen years our instruments have been sold under our own guaranty and during that time many chemists have tested them and never found an error. We may therefore consider our guaranty as sufficient.

"Ventzke's scale is based on 26.048 grams chemically pure sucrose of the specific gravity 1.10 in 100 cubic centimeters of water at 17.5° C.

"It is different with the French scale. This is based on the equivalent rotation of chemically pure sucrose and a 1 millimeter quartz plate.

"On account of these different methods of division the normal rotation for D light gave for 1 degree Ventzke = 0.3455 circular degrees and 1 degree Ventzke on the French scale = 0.3457 circular degrees.

"(See Landolt, *Das optische Drehungsvermögen organischer Substanzen*, page 162, and *Chemisch-physische Tabellen* von Landolt und Börnstein, page 230.)

"We are now confronted by the question: Are the values 0.3455 and 0.3457 per circular degree correct?

"Some years ago we personally made determinations of the Ventzke degrees with D light and at that time found 1° Ventzke, white light = 0.3463, resp. 0.3464 circular degrees D light. Your communication caused us to repeat these experiments with the improved saccharimeters at hand, which gave the following result:

1° Ventzke white light = 0.3467 circular degrees D light.

"We do not know whether the values given by Landolt and in the tables have been lately corrected; our carefully and accurately made experiments have nevertheless given different results.

* Communication from F. Schmidt and Haensch.

"Some time ago we asked the Physical-Technical Institute to make extended experiments on the constancy of the rotatory power of various kinds of quartz, to establish a normal, and thus lead to the adoption of an international scale for all saccharimeters. Our request has been favorably considered, and we may soon expect satisfactory results which will throw more light on this subject.

"We will not fail to communicate with you as soon as these investigations are completed and published."

The graduation of the Laurent instrument is fixed in such a way as will give for 16.19 grams of pure sugar in 100 true cubic centimeters a value of 100° on the scale, corresponding to an angular rotation of 21.67 for (α)_D.

The Scheibler color instrument is graduated also by the Ventzke scale, the same as is used by Schmidt and Haensch in their shadow instruments, giving, in sugar degrees, for 26.048 grams of pure sugar dissolved in 100 cubic centimeters, one hundred divisions equivalent to an angular rotation of 34.55 or 34.68, as given above.

The variations which may be caused by weighing in air instead of weighing in vacuo must also be taken into account. A flask standardized by weighing the calculated amount of water into it in air will be to a true 100 cubic centimeter flask, graduated in vacuo, as 100.155 cubic centimeters is to 100 cubic centimeters. The error of weighing the sugar in air may also be deduced from the following proportion, viz, 26.048 grams of sugar weighed out in air are equivalent to 26.064 grams weighed in vacuo. In making up a sugar solution, weighing 26.048 grams in the air and standardizing the flask in the air, each cubic centimeter of the solution will contain .260236 gram of sugar. A Mohr flask graduated to hold 100 grams of water at 17.5° has the following relation to a true 100 cubic centimeter flask, viz, 100.12 : 100 cubic centimeters. Instead of a true 100 cubic centimeter flask at this temperature holding 100 grams, as a Mohr flask does, it holds exactly 99.8747 grams of water.

These points must all be taken into consideration in the actual standardization of instruments. I think it is necessary that we should obtain a certificate of each instrument used from its maker stating the method of its graduation, and then use with that instrument the same flask and same weights which were employed in obtaining this graduation. If the instrument is used with a Mohr flask containing 100 grams of water weighed in air at a temperature of 17.5° , then we should use Mohr flasks for our analyses. If, on the other hand, the instrument is graduated by a true 100 cubic centimeter flask containing 100 grams of water at a temperature of 4° , then all our flasks should be graduated in this way whether they be weighed in air or in vacuo. In the same way, if the standard weights of sugar used in graduating the instrument are weighed in air, we should make our weighings in air; if, however, the standard weights of sugar are corrected for weight in vacuo, then we should correct also for weight in vacuo.

ABSTRACTS RELATING TO SUGARS AND ANALYTICAL METHODS.

INVERT SUGAR.

Jungfleisch and Grimbert* have shown that the rotatory power of pure levulose when observed directly differs much from that which is derived from observation in corresponding circumstances of an invert sugar considered as a mixture of equal weights of glucose (dextrose) and levulose.

Clerget's numbers obtained in 1849† have been confirmed by Tuschschmid.‡ Tuschschmid's formula was $\alpha D = -(27^{\circ}.9 - 0^{\circ}.32t)$, which is applicable to a liquor containing 17.21 grams of inverted sugar in 100 cubic centimeters. At different temperatures the rotatory power of pure levulose compared with the rotatory power of levulose calculated from invert sugar is as follows:

	Temperature.				
	0°.	5°.	10°.	14°.	20°.
αD pure levulose.....	101.22	98.42	95.62	93.38	90.02
αD levulose, calculated from invert sugar.....	108.54	105.34	102.14	99.58	95.74

These differences are probably due to certain unexpected peculiarities produced by the action of acids upon the levulose.

(1) It is shown that the rotatory power of crystallized levulose is not affected by the introduction of equal weights of dextrose; this last sugar, therefore, can not produce the differences noted.

(2) When pure levulose is subjected to the treatment by which invert sugar is made from cane sugar, it is found that its rotatory power is strongly affected. A solution of pure levulose which at 12° gave $\alpha D = -94.66^{\circ}$, gave $\alpha D = -96.78^{\circ}$ when it had been previously treated with 5 per cent strong hydrochloric acid and heated to 68° for half an hour. When sulphuric acid was employed the rotatory power was still more highly increased, reaching $\alpha D = -99.77^{\circ}$. These results were not notably affected when the acids were carefully neutralized before the observation was made. Oxalic acid acts like the mineral acids in this particular. Acetic and formic acids are without effect. In 1846 Dubrunfant § showed that the rotatory power of inverted sugar varied with the nature and proportion of the acid employed. A solution of cane sugar, inverted according to the method of Clerget, showed the rotatory power of the levulose $\alpha D = -101.3^{\circ}$; while the same solution inverted by another method, that is the addition of 5 per per cent of hydrochloric acid and heated to 68° for thirty minutes, showed $\alpha D = -96.52^{\circ}$. It is also demonstrated that acetic and formic acids employed with 5 per cent strength and at 100° , invert cane sugar completely in thirty minutes and give a liquor whose rotatory power remains constant even after prolonged heating, and in the invert sugar thus obtained the levulose possesses the rotatory power of pure levulose. In the conditions where pure levulose gave $\alpha D = -94.66^{\circ}$ we found after inversion with acetic acid for thirty minutes at 100° $\alpha D = -94.75^{\circ}$; and after heating for one hour $\alpha D = -94.48^{\circ}$, after heating with 10 per cent acetic acid for one hour $\alpha D = -94^{\circ}$; after heating with 5 per cent formic acid at 100° for thirty minutes $\alpha D = -94.80^{\circ}$. Moreover, it was seen that when hydrochloric acid was added to the solution inverted as above, the levulose underwent modifications similar to those which pure levulose suffers in the

* Comptes rendus, Vol. 107, p. 390.

† Annales de Chimie et de Physique, 3d series, Vol. 26, p. 175.

‡ Journal für prakt. Chemie, Vol. 2, 1870, p. 135.

§ Comptes rendus, Vol. 23, p. 38.

same circumstances. The conclusions reached by these experiments were as follows:

(1) Strong acids modify the rotatory power of levulose by increasing it more or less according to circumstances.

(2) The levulose of sugar inverted by the processes in ordinary use is not strictly identical with pure crystallized levulose.

Maumené* criticises the experiments of Jungfleisch and Grimbert, the abstract of which precedes, in a long article which in many places seems permeated with strong personal feeling. As a resumé of his criticism he states: First, inverted sugar, even when inverted by pure water, is never a mixture of equal weights of glucose and levulose or even of chylarlose. Second, glucose is a mixture of several hexeloses; one of these, left-handed hexelose, approaches very near in its composition to what is called levulose derived from inuline. It is very difficult to isolate it even at a freezing temperature, and it is unstable in a higher temperature. Another, optically neuter, which has been called inactose, is obtained by a complete transformation of normal sugar by means of nitrate of silver. The third is a non-fermentable hexelose. It occurs in the inversion of normal sugar by pure water or even by water which has been treated with a few ten-thousandths of acid. It is separated from the others by fermentation. The character of invert sugar is influenced, first, by the relative quantities of sugar, water, and acid; second, by the degree of heat; third, by the time of the reaction; fourth, temperature during the subsequent treatment with lime, saturation of the products by carbonic acid and the duration of the evaporation in a vacuum.

Inversion is produced by a series of molecular movements modified by these numerous influences, and the greatest precautions are necessary to obtain the same result even in like conditions.

Glucose preserves a certain quantity of a mixture of hexeloses properly named chylarlose, since it is extracted from the inverted sugar by capillary attraction, porous brick or porcelain, or blotting paper.

Jungfleisch and Grimbert have confirmed the alteration of left-handed hexelose or levulose, not upon this hexelose properly so called, but upon the inverted sugar by a comparison with a product of inuline, a product which can not be assimilated to inverted sugar without many errors.

The specific rotatory power of cane sugar is generally acknowledged to be independent of temperature. If, however, a solution of sucrose be made up to the standard volume of 100 cubic centimeters at a certain temperature and then polarized at different temperatures, it will show either an apparent increase or decrease in rotatory power as the temperature is lowered or raised. This is simply due to the fact of the contraction of the solvent, thus admitting a larger number of sugar molecules in a given length of the column at a low temperature than at a high temperature.

Wartzel† has determined this change in polarization in a large number of instances, and finds that the polarization expressed in degrees of cane sugar in a normal solution (26.048 grams in 100 cubic centimeters) changes about 0.1 of a degree for each difference of 2° in temperature. A solution polarized at 14° gave a reading of 95.6. The same solution polarized at 34° gave a polarization of 94.7; for a difference of 20°, therefore, the difference was 0.9 of 1 degree. In another experiment a difference of 24° showed a difference of 0.1 of a degree in polarization. On changing the temperature back to the original the original polarization was obtained. A solution that, polarized at 17°, gave 95.1° polarization, when cooled to 10° showed 95.5° polarization; when reheated to 17° it showed again 95.1°.

{From these numbers the importance of making the polarization at the temperature at which the solution is made up is at once seen. For this reason the solutions should all be made up at a given temperature in a place near that where the polarizations are

* Abstract from *Journal des Fabricants de Sucre*, March 27, 1889.

† *Deutsche Zuckerindustrie*, April 20, 1889. *La Sucrerie Belge*, June, 1889, p. 441.

made, and the temperature should not be allowed to change from the time the solutions are made up until the polarizations are complete.

As has already been said, most sugar flasks are graduated either at 15° or 17.5°. The mean temperature of laboratories in the United States is much higher than this, and it would probably be well to have all our flasks graduated at about 22°. Since, however, the volume of a flask will change very little within the limits given, viz, 15° to 22°, it is more important that the polarizations be made at the same temperature at which the solution is made up than that all the flasks should be graduated at a given temperature.—H. W. W.)

ABSTRACT OF A. WOHL'S PAPER ON CHARACTER OF THE CARBOHYDRATES.*

Kirchoff, in 1811, noticed the change of starch into dextrose by heating with acids, and Biot the changes in rotatory power produced in cane sugar by the same reagent. The tendency of all polysaccharides to be reduced to monoses has given rise to a rich literature. Further treatment of the monoses results in the formation of humus substances and of organic acids.

The important observation of Grimaux and Lefevre of the reformation of dextrinoids by heating pure glucose with HCl is also made the basis of some interesting deductions.

The time element in inversion has been studied by Wilhelmy and others. The invertive power of very small quantities of mineral acids in concentrated sugar solutions is pointed out, especially with a mere trace of HCl, which, when melted with sucrose, secures a complete inversion thereof, and that, too, without notable discoloration. Illustrations are given of the action of HCl on concentrated sugar solutions.

13.024 grams of sucrose were heated for thirty minutes in a stoppered flask at 100°, and then showed a polarization of 12°. With longer heating the left-handed polarization diminished, and also the quantity of copper precipitated. It is concluded from the diminution of the left-handed polarizing power of the invert sugar, caused by concentration of the solution and of the acid and by high temperature and duration of the invertive process, that the invert sugar formed is not pure levulose and dextrose but also contains a different sugar. If this diminution be due to a molecular condensation of the invert sugar formed, then it would take place also when pure invert sugar is heated with an acid. This experiment was tried with invert sugar and hydrochloric acid. Pure dextrose and levulose were used for these experiments. 3.425 grams of each were taken and made up to 50 cubic centimeters at 20°, polarizing 15.8°. 0.1714 gram of the mixed sugars gave 0.313 gram copper. On heating this, as before, with dilute HCl, both polarization and reduction were diminished. Heating with water alone gave no change, so that the condensation of the molecules of invert sugar is due to heating with acids.

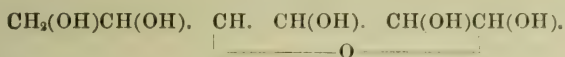
It was necessary, in order to elucidate the problem further, to note the action of HCl on concentrated glucose and levulose solutions. These results showed that the dextrose was but little affected by the treatment, and hence that the changes noted had been due to polymerization of the levulose.

An examination of the products formed by the action of a small quantity of acid on concentrated levulose solutions shows that dextrin-like (levulin-like) bodies are formed (levulosin). An 80 per cent solution of dextrose was heated at 105° with increasing quantities of acid. This treatment increased the polarization of the substance, and diminished its reducing power, indicating a polymerization and formation of dextrinoids. Whence it follows that the hydrolytic splitting up of the di- and poly-saccharides is not a simple process, but, together with the inverting action of the acid shown in the splitting up of the higher molecular weights, there is a synchronous reformation of the polymers. These phenomena give support to the opinion

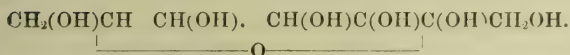
* Berichte, July 14, 1890, pp. 2084 *et seq.*

of Tollens, that the monoses are not pentaoyxaldehydes or pentaoyxketones but pentaoyxoxides, that is, aldehyd or keto- γ -lactones, in which the structural formulæ for dextrose and levulose are as follows:

Dextrose.



Levulose.



It is further shown that the usual methods of inversion use, without exception, excessive quantities of acid, and that the maximum levogyrous result and maximum reducing power are to be obtained only with very dilute acids or at low temperatures.

In order to convert pure sugar into colorless invert sugar it is only necessary to heat the solution at 95° for a half hour with 0.01 per cent HCl.

The above principles of inversion were also applied to starch, inulin, etc., on the supposition that the difficulty of securing a complete inversion of starch lay in the reformation of dextrin by the strong acid employed rather than in the natural refractory nature of the material, and experiments are given supporting this hypothesis.

Pure levulose.—Directions are given for the preparation of pure levulose as follows:

In an Erlenmeyer flask of 50 cubic centimeters, capacity put 50 cubic centimeters water and 5 cubic centimeters of HCl of a specific gravity sufficient to give 0.01 to 0.02 per cent HCl to weight of inulin. (For 200 grams inulin of 0.25 per cent ash content, 5 cubic centimeters normal HCl; for higher ash content, more). The 200 grams inulin, in fine powder, are then added, well shaken, and heated in boiling water (not in bath). After thirty minutes from the time mass is evenly heated the maximum of inversion is reached, the flask is removed from the boiling water. The sirup carrying some granules of inverted inulin is poured into one liter of warm absolute alcohol; a little blood carbon added and allowed to stand twenty-four hours and filtered. A few crystals of fruit sugar added to the filtrate causes a copious crystallization of pure levulose. A better yield is secured by evaporating the alcoholic filtrate to a thick sirup, and putting over H₂SO₄ in desiccator. A crop of crystals is thus obtained which resemble dextrose got in similar conditions. The crystal masses thus obtained are dissolved in three to four parts absolute alcohol, allowed to stand twelve hours, and the clear solution poured off. A few crystals of fruit sugar and rubbing with a glass rod cause the crystallization of the levulose to appear at once.

SOME FACTS RELATIVE TO THE ANALYSIS OF SUGARS.

By JUNG FLEISCH AND GRIMBERT.*

Some facts which have been developed in the experience of the authors lead them to doubt the principle of the method of Clerget. The process of Clerget may be expressed as follows:

Let A be the deviation produced by 1 decimeter of the liquor in which it is desired to find the weights x and y of the sucrose and of the inverted sugar. Let A' represent the deviation of the same liquid inverted by strong acid without changing its concentration; then $(a)_D = 67.31$ and $(a)_D = -24.31$, this being the expression for the rotatory power of the sucrose and inverted sugar; then the two equations which will give the value of x and y are as follows:

$$\frac{67.31}{100}x - \frac{24.31}{100}y = A; \text{ and } 24.31(x+y) = A'.$$

* Comptes rendus, vol. 109, p. 867.

The results obtained in this way are generally inexact. Contrary to what is supposed in the first equation, inverted sugar exists in natural sugar products which have not been subjected to the action of strong acids and its rotatory power, which at first is about $(a)_D = -21.16$, increases greatly during inversion.

Therefore the calculation indicates a plus error for the second an error proportionately to $\frac{y}{x}$, this increasing with the weight of inverted sugar preëxisting; moreover,

the calculation exaggerates the error committed.

It is known that if such a sugar be treated with strong and dilute acids, the product is always more strongly left-handed in the first than in the second case. When analysis is made on crystallized sugar of commerce, which is always poor in inverted sugar, the difference is very little and may be neglected, but such is not the case with sugars rich in inverted sugar. When the substances analyzed contain glucose and levulose in unequal quantities, the other compounds are sometimes determined by the aid of an analogous calculation by estimating a third equation from the reduction of alkaline copper solution, but the same objection still applies. Acetic acid acts upon saccharose without modifying the levulose, but with certain salts certain facts have been established which tend to prevent its general use. These facts may be summarized as follows:

(a) Alkaline acetates, although they do not prevent the inversion of sucrose by strong acids employed in excess, interfere with the inversion by acetic acid even when employed in very great excess. In presence of 1 molecule of acetate of soda 1 molecule of sucrose is not completely converted even at 100° during a half hour by a weight of acetic acid equal to 80 molecules.

(b) Alkaline citrates, formiates, lactates and tartrates, the acetate of zinc and lead act in a similar manner. The acetate of lime is much less active.

(c) The salts of strong monobasic acids do not prevent inversion by acetic acid. The neutral salts of strong bibasic acetates diminish the inverting power when the base is monovalent, but not when the base is bivalent. The acid salts of strong polybasic acids do not retard the inversion by acetic acid, but sometimes even effect it themselves.

Details of the work will be given in a future memoir.

ESTIMATION OF GLUCOSE WITH ONE-TENTH NORMAL COPPER SOLUTION, ACCORDING TO SOLDAINI'S METHOD.*

To avoid the decomposition of stronger solutions, such as the normal solution, Soldaini proposes the use of a one-tenth normal solution made as follows: 3.464 grams crystallized copper sulphate ($\text{CuSO}_4 + 5\text{H}_2\text{O}$) and 297 grams of KHCO_3 dissolved in 1,000 cubic centimeters of water. For the estimation of glucose with the one-tenth normal solution, 100 cubic centimeters of this solution are heated to boiling and the glucose solution added gradually until complete reduction takes place. The 100 cubic centimeters of the one-tenth normal solution correspond to 0.05 gram glucose.

QUICK ESTIMATION OF SUGAR BY ONE-TENTH COPPER SOLUTION.

By J. E. POLITIS.†

The one-tenth copper solution is made as follows: 24.95 grams crystallized copper sulphate, 140 grams of the tartrate of sodium and potassium, 25 grams caustic soda. The above substances are dissolved in distilled water, mixed together, and the mixture made up to 100 cubic centimeters. There is also required a one-tenth normal hyposulphite solution made as follows: 24.8 grams pure crystallized hyposulphite of soda dissolved in distilled water and made up to 1 liter. There is also required a

* *Chemisches Central-Blatt*, No. 9, 1889, volume 2, p. 389.

† *Ibid.*, p. 390.

one-tenth normal iodine solution made by dissolving 12.7 grams of iodine in alcohol and making the volume up to 1 liter. The titration is performed as follows: 50 cubic centimeters of the copper solution is heated to the boiling point. There are then added 10 centimeters of the sugar solution, which is allowed to boil, made up with water to 100 cubic centimeters, and 50 cubic centimeters filtered off. The filtrate is made slightly acid, and iodide of potash added in slight excess, together with some starch solution, and the iodine which is set free is titrated with the solution of hyposulphite which corresponds to the copper which has not been reduced. The one-tenth normal solution of iodine serves for determining the strength of the hyposulphite of soda solution. Full details of this method will be found on page 145.

ESTIMATION OF SUGAR BY FEHLING'S SOLUTION.

BY H. CAUSSE.*

To 10 cubic centimeters of ordinary Fehling's solution are added 4 cubic centimeters of a 5 per cent solution of potassium ferrocyanide and 20 cubic centimeters of water. On the precipitation of the cuprous oxide by reducing sugar, the potassium ferrocyanide dissolves it as soon as it is formed, preventing the occurrence of a yellow color and keeping the reagent perfectly clear. The disappearance of the blue copper color is taken as the end of the reaction. The author of this method says that the potassium ferrocyanide is without action either on hot or cold Fehling's solution. On cooling the liquid turns brown and deposits colorless crystals.

NOTE.—The above method was tried in my laboratory with the following results: A solution containing reducing sugar gave, according to the usual method, 15.7 per cent; with the addition of the amount of ferrocyanide mentioned above, it showed 13.1 per cent. When 13.1 per cent of the sugar solution were run into the Fehling's solution without ferrocyanide, the blue color was still distinctly marked, even in the presence of the yellow cuprous oxide. From the above it is seen that a part of the copper seems to be consumed by the ferrocyanide, probably with the production of ferri-cyanide. The method, therefore, is not applicable.—(H. W. W.)

ESTIMATION OF RAFFINOSE.†

Let x = sugar in 100 cubic centimeters.

y = raffinose in 100 cubic centimeters.

P = rotation before inversion.

P' = rotation after inversion at temperature t .

$$102x + 158.4y = 16.20P.$$

$$-(44 - 0.5t)x + (75 + 0.5t)y = 16.26P'.$$

$$(\text{whence } y = 16.26 \times \frac{(44 - 0.5t)P - 102P'}{158(44 - 0.5t) + 102(75 + 0.5t)})$$

The operation is carried on in the following manner:

One hundred grams of sugar are shaken for some time in a flask of 250 cubic centimeters capacity, with a narrow neck, with 150 cubic centimeters of methyl alcohol to which a few drops of alum have been added. One hundred cubic centimeters of the solution are taken and distilled in a flask until about 40 cubic centimeters of the alcohol has distilled over. Twenty cubic centimeters of water are then added to the flask and afterwards some subacetate of lead, until no further precipitation is produced. A small quantity of moist alumina is then added, the volume made up to 100, filtered and polarized. Fifty cubic centimeters of the filtered liquid are evaporated to drive off the alcohol, the residue dissolved in water, to which one-tenth its volume of strong hydrochloric acid has been added, and the volume made up to 50 cubic centimeters.

* Bul. Soc. Chim., volume 50, page 625.

† Gunning, Scheibler's Neue Zeitschrift, 1888, XXI, 335.

The temperature is carried to 68° to invert the cane sugar, and after cooling, the solution is again polarized. The quantity of raffinose found by the formula is multiplied by 1.5 and gives thus the percentage of raffinose in the sugar. Methods of operation are also given for the analysis of raw sugars and molasses. The formula, with full details of method, is given on page 141.

ESTIMATION OF ASH IN SUGARS AND SIRUPS WITHOUT SULPHURIC ACID.*

Oxide of zinc is used, which has the following qualities to recommend it:

It is white, infusible, forms only a single oxide, is easily obtained in impalpable powder, is not hygroscopic, and it yields its oxygen as easily as the oxide of copper in the presence of organic matters and, in a measure indefinitely, because the zinc reduced to a metallic state is reoxidized immediately, and is susceptible therefore of furnishing a new quantity of oxygen to the substance until its complete combustion. The operation is conducted as follows:

In the case of sugar, 5 grams are weighed in a platinum dish, to which are added 0.05 gram oxide of zinc and a few drops of distilled water. The carbonizing is then carried on with due precaution over a Bunsen burner. The mass on melting absorbs evenly the oxide of zinc. After the carbonizing is completed the capsule is placed in a muffle, heated to low redness, and the incineration is completed after three-quarters of an hour or an hour at most. The ash is weighed and the 50 mg. of oxide of zinc subtracted. The capsule should be dried in a desiccator and weighed as rapidly as possible, since the carbonate of potash which is present is highly hygroscopic.

For sirups, the operation is carried on in the same manner, except sometimes it is preferable to weigh only 3 grams instead of 5. The capsules of platinum do not seem to suffer anything from the presence of the oxide of zinc, but porcelain dishes can be used instead.

ESTIMATION OF SUGAR IN THE BEET. †

It is stated that the amount of sugar in the beet, estimated by digestion in water, is, on an average, two-tenths per cent higher than by digestion in alcohol. Ninety-eight comparative determinations were made by the alcohol and water methods and the mean by alcohol polarization was 12.88 per cent and the mean by the water polarization 12.98 per cent. Careful determinations were also made in comparing the alcohol extraction with the cold water digestion on a very finely-divided beet pulp according to the Pellet method. The means of twenty-eight determinations were as follows: Alcohol extraction, 12.72 per cent; Pellet's cold water diffusion, 12.73 per cent; ordinary polarization in water, 12.81 per cent. It is recommended that alcohol extraction be used in all cases where scientific exactness is required.

INFLUENCE OF THE PRECIPITATE FORMED BY ACETATE OF LEAD UPON POLARIZATION. ‡

Let S equal the weight of 100 cubic centimeters of juice; B, the weight of 10 cubic centimeters acetate of lead solution; N, the weight of the precipitate formed; F, the weight of the filtered liquid; then $S + B = N + F$. If F be replaced by the product of the volume V by the density d , we obtain $S + B = N + Vd$. If the volume of the precipitate be represented by v , we have the equation $V + v = 110$, whence $V = 110 - v$. From these equations the following one is derived:

$$v = \frac{110d + N - (B + S)}{d}$$

From this formula is easily deduced the volume of the lead precipitate.

* Lucien, Bulletin de L'Association des Chimistes, vol. 6, p. 356.

† Petermann, Zeitschrift des Vereins für die Rübenzucker-Industrie des Deutschen Reiches, 1889, p. 170.

‡ Ziegler, La Sucrerie Indigène, June, 1889, page 622.

Example.

Weight of 100 cubic centimeters of juice, plus 10 cubic centimeters of lead acetate = 118.509 grams = S + B. The specific gravity of the filtered liquid = $1.061 = d$. The weight of the dried precipitate was found to be $3.005 = N$, then by the formula above $v = 1.136$. It is thus seen that the lead precipitate occupies a little more than 1 per cent of the total volume.

ESTIMATION OF ASH IN SUGARS BY INCINERATION WITH BENZOIC ACID.*

To avoid the correction of one-tenth, as proposed by Scheibler, and one-fifth as proposed by Girard and Violette, when sugars are burned with H_2SO_4 , Boyer suggests incineration with benzoic acid, as giving the real quantity of mineral matter without correction.

The benzoic acid is dissolved in alcohol of 90 per cent, 25 grams of the acid to 100 cubic centimeters of alcohol. 5 grams of the sugar are weighed in a capsule and moistened with 1 cubic centimeter H_2O . The capsule is heated slowly, in order to caramelize the sugar without carbonizing it; 2 cubic centimeters of the benzoic acid are next added and the capsule warmed until all the alcohol is evaporated; the temperature is then elevated until the sugar is converted into carbon. The decomposing benzoic acid produces abundant vapors which render the mass extremely porous, especially if a circular motion is imparted to the capsule. The slow heating is continued until all the benzoic acid is volatilized.

The carbon obtained is voluminous and of a brilliant black color. The incineration is accomplished in a muffle at a low red heat. The capsule should be weighed quickly when taken from the desiccator, in order to avoid the absorption of water by the alkaline carbonates. Benzoate of ammonia may be employed instead of benzoic acid, and the analyst should previously assure himself that neither the acid nor the ammonia salt leaves a residue on incineration. In addition to giving the mineral matters directly, this method permits the determination of their composition also, a matter of no small importance.

NOTES ON POLARIZED LIGHT.†

Experiments were made to determine what thickness of quartz gives the best sensitive tint for polarimetric work. Biot has said that the best tint is given by a piece of quartz 3.75 millimeters thick in a bright field. In most modern polarimeters the sensitive tint is given by a 7.5 millimeter quartz in a dark field. Experiments made with pieces of quartz 3.75, 11.25, and 7.5 millimeters in a dark field showed that the 3.75 millimeters was more sensitive than the 11.25 millimeters to small rotations, but the 7.5 millimeters seemed the best of the three. The sensitive tints of the German experimenters are decidedly redder than Biot's or those generally used in England.

In speaking of rotary polarization it is customary to say that the plane of polarization is rotated, but the author thinks it equally correct to say that the light itself is rotated. The use of bi-quartzes for rotation experiments was condemned, since it was found almost impossible to get them cut with such accuracy as to give a uniform tint, and if the light be slightly elliptically polarized considerable error may be introduced. The shadow method of polarimetry is preferred. The rotation power of liquids is believed to be due to some kind of skew symmetry possessed by the molecules, the average effect of which is observed.

NOTES ON THE ESTIMATION OF RAFFINOSE AND INVERT SUGAR.

According to Herzfeld and Meissl's directions it is possible to estimate saccharose in the presence of raffinose and invert sugar in the presence of saccharose. Accu-

* Comptes, rendus, 111.

† Prof. S. P. Thompson, Proceedings of Physical Society, Chemical News, vol. 59, No. 1541, p. 276.

rate results are, however, not obtained when all three sugars are present, as the rotation caused by invert sugar is not shown in Herzfeld's formula while the presence of raffinose causes an error in the direct polarization which is used in Meissl's table.

J. Wortmann recommends the following method with a somewhat complicated calculation (*Zeitschr.* 39, 767). The approximate amount of invert sugar present is determined with Fehling's solution prepared according to Soxhlet and the formula

$$N = \frac{Cu \cdot 47}{q},$$

when Cu is the copper found, q the weight of substance used, and 47 the average factor for Meissl's table. The value for N thus found is substituted in the following formulæ:

$$\text{I. per cent saccharose } S = \frac{0.9598 P - 1.85 P' - 0.277 N}{1.5648}$$

$$\text{II. per cent raffinose } R = \frac{P - S + 0.3103 N}{1.85},$$

where P is the direct, P' the indirect polarization (for whole normal weight). Therefore $P - 1.85 R$ is the total rotation caused by saccharose and invert sugar, and using this to find Meissl's factor, we can easily arrive at the actual per cent of invert sugar, J. This value J is then substituted for N in formulæ I and II and by calculation the exact quantity of saccharose and raffinose found.

The formulæ I and II are founded on the following basis, which was established by Herzfeld and others:

The factor of rotation of raffinose, with reference to saccharose, is $1.85 = b$

The factor of rotation for inverted raffinose, with reference to saccharose, is $0.9598 = c$ } at 20 C.

The factor of rotation for inverted saccharose, with reference to saccharose, is $0.3266 = a$ }

26.048 grams saccharose after inversion, give a left-handed rotation of 32.66; since, however, 26.048 grams saccharose give 27.4191 grams invert sugar, this rotation, 32.66, is caused by 27.4191 grams invert sugar, and 26.048 grams invert sugar cause a rotation of 31.03, from which the rotatory factor for invert sugar is found to be $0.3103 = d$.

By applying these values the following equations may be formed:

$$P = S + bR - dN. \quad (1)$$

$$P' = -aS + cR - dN. \quad (2)$$

$$R' = \frac{P - S + dN}{b} \quad (1)$$

$$P' = -aS + \frac{cP - cS + cdN}{b} - dN \quad (2)$$

$$bP' = -abS + cP - cS + cdN - bdN$$

$$bP' = -(ab+c)S + (cd-bd)N + cP$$

$$S = \frac{cP - bP' - bd - cdN}{ab+c}$$

$$R = \frac{P - S + dN}{b} \quad (1)$$

or, by substituting the values of a, b, c , and d , the above formulæ I and II.

Estimations made gave results closely agreeing with the known composition of the solutions.

THE DETERMINATION OF RAFFINOSE IN THE PRODUCTS OF THE BEET-ROOT MANUFACTURE, BY J. W. GUNNING.*

With regard to the directions for the estimation of raffinose published by the German customhouse, the author reports the results of investigations made during the last year in the official Dutch sugar laboratories, of which he is director. The accuracy of the method given in the official directions is limited to 0.33 per cent of raffinose, and no method is known which detects smaller amounts of raffinose with

* *Z. f. anal. Chem.*, 1889, p. 45, from *Chem. Zeitg.* 1889, No. 6.

any accuracy. The author, however, considers the assumption that raffinose never occurs in quantities of less than 0.3 per cent to be wrong. The results obtained with products containing 3 per cent or more of raffinose show the accuracy of the German inversion method. Other mixtures may be brought within this percentage of raffinose by concentrating before actual analysis, and Scheibler applied the greater solubility of raffinose as compared with saccharose to accomplish this. Scheibler's method for the estimation of raffinose, however, gives too high results, and Lotmann's modification failed to correct the error. Ekenstein, the director of the royal laboratory at Amsterdam, has found the cause of the error in Scheibler's and Lotmann's method, and has thus shown a way of solving the problem. Methyl alcohol (similarly wood spirits, though in a much less degree) dissolves from the solid sugars not only the raffinose but also by far the most of the adherent molasses. Thus Scheibler obtained results which were too high. Lotmann's supposition that lead acetate precipitates from the methyl alcohol solution nothing influencing the rotation but raffinose, is incorrect. When the methyl alcohol is almost anhydrous the raffinose is completely precipitated, but also about ten times its weight of saccharose. Lotmann's and Scheibler's methods are, therefore, subject to the same error as regards the percentage of raffinose found. The accurate investigation of the influence which the gradual dilution of the methyl alcohol with water exerts upon the precipitates obtained with lead acetate opened a way for the accurate accomplishment of the purpose. The outlines for a raffinose estimation in sugar products are: Extraction with methyl alcohol (or wood spirits), partial removal of the solvent by heating, dilution with water, precipitation with lead acetate, and polarization of the filtrate before and after inversion.

In the Holland laboratories the Laurent shadow instrument is used (16.26 grams, normal weight). The following equations are applied in this case. Supposing: x = grams saccharose in 100 cubic centimeters of solution, y = grams raffinose, P polarization before inversion, p the same after inversion, and t = temperature.

$$\begin{aligned} \text{Then } 102x + 158.4y &= 16.26P \\ - (44 - \tfrac{1}{2}t)x + (75 + \tfrac{1}{2}t)y &= 16.26p \\ \text{Whence } y &= 16.26 \frac{(44 - \tfrac{1}{2}t)P - 102p}{158(44 - \tfrac{1}{2}t) + 102(75 + \tfrac{1}{2}t)} \end{aligned}$$

The constants used are for a solution in 60 to 70 per cent alcohol, and have been determined in solutions of various concentration.

Following are the details for the method of estimating raffinose in sugar products:

(a) *For first products.*—One hundred grams are shaken in a stoppered narrow-necked 250 cubic centimeter flask with 150 cubic centimeters of commercial wood spirits which have been previously mixed with a few drops of potash-alum solution. The latter is added to neutralize the alkaline reaction of the sugar. The precipitated sulphates also carry down coloring matter. A 100 cubic centimeter flask is filled to the mark with the solution, 40 cubic centimeters removed by distillation, 20 cubic centimeters of water added, and lead acetate as long as a precipitate forms. A little moist aluminum hydrate is then added, the flask filled to the mark with water, well shaken, and the solution filtered rapidly and polarized. Fifty cubic centimeters of this filtrate are heated until all the methyl alcohol has been driven off, made up to 50 cubic centimeters with water, 5 cubic centimeters of hydrochloric acid (36 per cent HCl.) added, and heated for 10 minutes at 68° centigrade. Then it is cooled rapidly to 20° centigrade, and polarized in the 220 millimeter tube. The value y (raffinose) calculated from the equation when multiplied by 1.5 will give the percentage of raffinose.

Within 0.05 per cent of raffinose can be determined in sugars of high purity by this method. But to extract such small amounts rapidly some potassium acetate must be added to the solvent. With regard to the German report, the author notes that he does not know of any commercial article in Holland which would influence the custom-house method of examination.

(b) *For solid-after products.*—The raffinose in these is only dissolved very slowly and incompletely by methyl alcohol, and a modification of the method is therefore necessary. Thirty grams of raw sugar are treated in a graduated flask with 6 to 9 cubic centimeters of water and enough potash-alum solution to neutralize the alkalinity of the sugar. The sugar is then dissolved by heat and about 120 cubic centimeters of wood spirits added with continual shaking. After cooling it is made up to the mark with wood spirit, a little powdered sugar added, and the flask shaken frequently during one hour. After from 10 to 11 cubic centimeters of wood spirit have been added to correct for the volume of sugar separated, the liquid is filtered and the estimation continued as directed under (a). The value for raffinose found multiplied by 5 gives the percentage of raffinose. These estimations are accurate within 0.1 per cent of raffinose.

(c) *Molasses.*—On account of the solubility of molasses in methyl alcohol or wood spirit no concentration of the raffinose can take place, and the method is therefore very similar to the German inversion method. Twelve grams molasses are mixed in a 150 cubic centimeter flask with 12 grams water and the amount of potash-alum solution necessary for neutralization dissolved, and wood spirit added to the mark. It is then shaken, filtered, and the filtrate analyzed as under (a). The value found multiplied by 12.5 gives the percentage of raffinose present. In America the estimation of raffinose in raw sugars is made by a method only slightly varying from the German. (See Th. Breyer, *Chemiker Ztg.*, 1889, 35, 499.)

SACCHARIMETRY—EXAMINATION OF SUGAR AND BEETS—VARIOUS METHODS.

While considering the various investigations concerning the invert sugar determination by Soldaini's reagent, which so far have not arrived at any constant results on account of the uncertain percentage of copper present, Striegler (*Zeitschr.*, 39, 773) thought it would be of value to make a number of experiments for the purpose of finding a method by which the reagent could be prepared with a definite copper content. He beforehand studied the reactions which take place when the reagent is prepared according to Bodenbender and Scheller, and was thus enabled to elaborate a method by means of which a constant solution can be easily prepared. He has used this reagent in invert sugar determinations and has obtained results almost identical with those of Bodenbender and Scheller. In these experiments all the directions given by Degener and Schweitzer and later by Pareus (*Jahresb.*, 28, 119–121) have been carefully followed so as to arrive at results absolutely free from error. Analyses of various quantities of the reagent prepared by the same method show:

(1) That a large amount, almost one-half, of the potassium bicarbonate used has been decomposed with the evolution of carbonic acid.

(2) That the amount of copper dissolved varies considerably between 131.1 and 159.7 mg. copper in 100 cubic centimeters; with regard to Preuss' figures even from 104 to 187 mg. copper in 100 cubic centimeters.

(3) That the quantity of copper carbonate dissolved is very low as compared with the quantity used. (Used a quantity corresponding to 0.727 gram copper, dissolved at the most 0.1597 gram copper in 100 cubic centimeters.)

Further experiments have proved that on dissolving the potassium bicarbonate in hot water a large amount is decomposed, and that in preparing the reagent more is used than can remain in solution at the ordinary temperature. It is therefore necessary after preparing the reagent to decompose the bicarbonate at least in part, so as to prevent any excess from crystallizing out. This can easily be accomplished by boiling.

Profiting by the results of further experiments, the author prepared a reagent of definite composition as follows:

An amount of copper sulphate corresponding to 0.1625 gram copper in 100 cubic centimeters was accurately weighed out, dissolved in cold water, made alkaline with soda lye, and the precipitate washed well. The usual amount of potassium bicar-

bonate was then added and the whole heated at 40° to 45° C. until the bicarbonate had dissolved and then at 60° until complete solution of the hydroxide of copper took place. This operation requires from one and a half to two hours, the preparation of larger quantities occupying a correspondingly larger amount of time. The solution was boiled some time to destroy the bicarbonate, cooled, and made up to the original volume.

Analyses show, as could be surmised beforehand, that this solution gives constant results; differences which could be ascribed to a varying carbonic acid content did not occur; we must naturally suppose that enough bicarbonate has been destroyed to prevent any crystallization.

The following method of preparation was finally adopted as serving the purpose:

To prepare 2 liters of the reagent, exactly 12.77 grams of pure, finely powdered copper sulphate were dissolved in cold water, precipitated with soda lye and the precipitate collected on a filter. A simple contrivance was used to facilitate washing. A flask holding about three-quarters of a liter was closed with a perforated stopper through which passed a glass tube about 6 to 7 centimeters long and 5 millimeters wide. The flask was inverted in such a manner over the funnel that the end of the tube was just below the level of the liquid in the filter. This arrangement is automatic and reliable. The washed hydrate was carefully transferred to a porcelain dish, removing the last particles from the filter with the wash bottle, mixed well with a glass rod, and then washed into a 2,500 cubic centimeter flask together with 597.7 grams potassium bicarbonate. Enough water was added to make the volume about 2,000 cubic centimeters. This was heated on the water bath to 45° C., frequently shaking, until the bicarbonate had dissolved, and then direct heat applied to dissolve the hydrate, not allowing the temperature to rise over 60° to 70° C. After complete solution the reagent is boiled for one to one and a half hours so as to decompose the bicarbonate, allowed to cool, transferred to a 2 liter flask, made up to the mark, and filtered. It is unnecessary to use a reflux condenser or to make up to 2 liters beforehand, as the escape of carbonic acid causes a concentration which must be corrected by the addition of water.

The solution in itself is stable, not even boiling causing decomposition. If, however, it is diluted with five times its volume of water, a bluish-green precipitate appears, which becomes black on boiling. This precipitate is therefore copper oxyhydrate, which is converted into black copper oxide on heating. This observation induced the author to examine the action of water on the usual Soldaini reagent. He found that when diluted with about twenty times its volume of water it also gave a precipitate of black oxide upon heating. This seems to indicate that the copper in Soldaini's reagent is not present as carbonate, but rather as hydrate.

The behavior of basic carbonate of copper showed another way of preparing a constant reagent.

The basic carbonate prepared from 50 grams copper sulphate is heated for five or six hours with 300 grams potassium bicarbonate and about 700 cubic centimeters of water, the heat being kept at 45° C. as before until the bicarbonate has dissolved and then at 60° C. The solution is filtered and the excess of bicarbonate allowed to crystallize. The filtrate contained, in 100 cubic centimeters, 0.2882 grams copper and a quantity of potassium hydrate, corresponding to 36.7 grams potassium bicarbonate.

To prepare 1 liter of Soldaini's reagent (0.1625 gram Cu and 29.7 grams HKCO_3 in 100 cubic centimeters), 564 cubic centimeters of this solution are required, which contain 207 grams of the bicarbonate. It is therefore necessary to add 90 grams HKCO_3 or an equivalent amount of K_2CO_3 , the use of the latter avoiding subsequent boiling for the purpose of destroying the excess of bicarbonate. A solution thus prepared could not be distinguished from another prepared by the first method. It depends altogether on the conditions whether one or the other should be preferred. If small quantities, for instance 2 liters, are to be prepared, the first is best applied; but if large quantities are required, as in manufacturing laboratories, where a steam bath is always at hand and the time is immaterial, then the last method is best followed,

The property of Soldaini's reagent to decompose when much diluted explained the varying results obtained in the first investigations upon its reduction by invert sugar. The conditions for this decomposition are fulfilled as soon as we begin to wash, especially if hot water is employed. To avoid this the author rejected the addition of water after boiling with the invert-sugar solution and substituted washing with a cold solution of potassium bicarbonate until all the copper had been removed, following with water to remove all the alkali.

The author then gives examples to show that results are obtained which agree with those of Bodenbender and Scheller.

Following are several contributions to the estimation of invert sugar by means of various copper solutions. Ettore Soldaini writes:*

"As I required a copper solution for the determination of glucose while making some special agricultural investigations, I asked myself whether I should use the popular Fehling's solution or should prefer (Arturo) Soldaini's reagent, which is prepared from copper sulphate and potassium bicarbonate and is a solution of copper carbonate in potassium bicarbonate.†

"On looking over the literature ‡ on this subject and considering the favorable manner in which the new solution had been received, as also the faults peculiar to Fehling's solution, I decided to use the former reagent; not, however, without being astonished at the high amount of copper directed for its preparation, which can not dissolve in a potassium bicarbonate solution of the given concentration, even when the modifications of Bodenbender and Scheller, which seem to enable a stronger solution, are followed. § In an actual experiment with the method of these authors, in which 40 grams of crystallized copper sulphate were dissolved, precipitated with 40 grams crystallized sodium carbonate, and washed to remove sulphates, the resulting basic carbonate would not dissolve completely after heating ten minutes on the water bath with a solution of 416 grams potassium bicarbonate, subsequent dilution to 1,400 cubic centimeters and again heating with reflux condenser for two hours. Upon filtering a blue liquid was obtained which was found to contain an amount of copper corresponding to 10.17 grams $\text{CuSO}_4 + 5\text{H}_2\text{O}$. For the Cu determination I employed Fresenius's method of precipitating in a platinum dish by means of zinc. By preparing the reagent several times and determining the copper I found the latter to vary from 1.856 to 1.845 grams, which latter figure would correspond to 7.25 grams $\text{CuSO}_4 + 5\text{H}_2\text{O}$ per liter.

"In other words, 10.15 grams $\text{CuSO}_4 + 5\text{H}_2\text{O}$ were sufficient to saturate the 1,400 cubic centimeters of reagent with copper under the conditions given. Soldaini's reagent can therefore be made of a constant strength by using this weight of $\text{CuSO}_4 + 5\text{H}_2\text{O}$ or less. If the usual method of preparation is followed, 11 grams should be used instead of 40 grams for 1,400 cubic centimeters.

"As these investigations show the impossibility of preparing a normal copper solution, I have adopted the one-tenth normal, dissolving 3.464 grams $\text{CuSO}_4 + 5\text{H}_2\text{O}$ and 297 grams KHCO_3 in 1,000 cubic centimeters of water, as I foresaw that this would give a much more delicate and stable reagent. It seemed unnecessary to precipitate the copper beforehand with sodium carbonate, and I prefer to add the solution of copper sulphate (or even the powdered salt) to the solution of potassium bicarbonate in a flask.

"Bodenbender and Scheller's directions concerning the washing of the copper carbonate may cause the assumption that the presence of sulphates exerts an influence on the delicacy of the reagent. Experiments have shown this to be not so, and that

* Zeitsch., 39, 933.

† Gazzetta chimica italiana (1876), 6, 322; Berl. Ber. (1876), 9, 1126; Z. f. anal. chem. 16, 248.

‡ Degener u. Schweitzer, Zeitsch., 1886, 110; Bodenbender u. Scheller, Zeitsch., 1887, 145; Preuss, Zeitsch. 1888, 735.

§ Zeitsch. 1887, 147.

0.0005 gram glucose dissolved in 10 cubic centimeters can easily be detected when this is boiled for ten minutes with an equal volume of the reagent. The copper separates as intensely red suboxide. Under the above conditions less than the given amount of glucose can not be detected. If, however, the test is made in the manner which I will now give, then 0.00025 gram of glucose can easily be detected. The concentrated solution of the latter is mixed with just enough reagent to color it slightly and evaporated to dryness on the water-bath. If glucose is present, the porcelain dish will show a rose-colored residue, which in the absence of glucose would be bluish-green. Addition of water will show the color more distinctly. To avoid mistakes it is well to make a blank with the reagent similarly diluted.

"The quantitative determination with this reagent $\left(\frac{N}{10}\right)$ must be made as follows: Measure out 100 cubic centimeters (corresponding to 10 cubic centimeters of a solution containing 0.05 gram pure glucose), heat until boiling, and add the unknown solution slowly until all the copper is reduced. When the approximate number of cubic centimeters of the sugar solution required is thus determined, the final estimation is made by boiling 100 cubic centimeters of the reagent for five minutes in a 200 cubic centimeter flask, adding the required volume of sugar solution from a burette, boiling fifteen minutes, and filtering after the liquid has been cooled rapidly. The filtrate should contain neither glucose nor copper.

"This method gives such rapid and satisfactory results that I am induced to recommend the use of the $\frac{N}{10}$ copper solution."

A RAPID METHOD FOR THE ESTIMATION OF SUGAR WITH $\frac{N}{10}$ COPPER-ALKALI SOLUTION.*

"The determination of sugar with Fehling's solution would be accurate and rapid enough if the end of the reaction, that is, the complete decolorization of the alkaline copper solution, was easy to determine. The suspended copper suboxide makes this very difficult. To avoid this inconvenience and to make the determination more accurate and rapid, the author uses a definite amount of sugar solution, an excess of $\frac{N}{10}$ copper solution, and estimates the excess according to De Haen's method, with potassium iodide and sodium hyposulphite. The following solutions are required:

"(1) $\frac{N}{10}$ copper solution consisting of 24.95 grams pure copper sulphate, 140 grams sodium-potassium tartrate, 25 grams pure sodium hydrate, and sufficient water to make 1 liter.

"(2) $\frac{N}{10}$ solution of sodium hyposulphite, 24.8 grams per liter.

"(3) $\frac{N}{10}$ iodine solution, 12.7 grams per liter. The three solutions must correspond exactly and 1 cubic centimeter of the copper solution is equivalent to 0.0036 gram glucose.

"The estimation is made as follows:

"Fifty cubic centimeters of the copper solution are boiled in a porcelain dish and 10 cubic centimeters of a sugar solution added, which contains about 1 gram glucose in 1,000. The whole is heated for five minutes, made up to 100 cubic centimeters, and exactly 50 cubic centimeters filtered into a beaker. The blue liquid is made slightly acid, a slight excess of potassium iodide and some starch solution added, and the iodine estimated by means of the $\frac{N}{10}$ sodium hyposulphite solution. This iodine corresponds to the unreduced copper in the liquid, and the copper required

* J. E. Politis (Jour. de Pharm. et de Chim., 20, No. 2, July, 1889; Zeitsch., 39, 935).

by the glucose can be calculated by difference. The number of cubic centimeters of $\frac{N}{10}$ $\text{Na}_2\text{S}_2\text{O}_3$ solution required is deducted from 25 and the result will be the number of cubic centimeters of copper solution, which have been reduced by 5 cubic centimeters of the sugar solution.

Example.—Fifty cubic centimeters $\frac{N}{10}$ copper solution were boiled with 10 cubic centimeters of diabetic urine which had been diluted to five times its volume and the estimation completed according to the above directions. Eleven cubic centimeters of $\frac{N}{10}$ $\text{Na}_2\text{S}_2\text{O}_3$ were required to completely decolorize the liquid; $25 - 11 = 14$ cubic centimeters of copper solution which had been reduced by one-half of the sugar solution; that is, 5 cubic centimeters of diluted or 1 cubic centimeter of the original urine. As 1 cubic centimeter of copper solution corresponds to 0.0036 gram glucose, 1 cubic centimeter of urine contained 0.0504, or 1 liter 50.4 gram glucose."

Scheller, in a preliminary notice, states that Soldaini's reagent can be made of a definite composition by dissolving 15.8 grams pure copper sulphate and 7.2 grams potassium hydrate respectively in 100 cubic centimeters of water, mixing, and adding to 1,700 cubic centimeters of a solution of 594 grams of potassium carbonate. It is then heated on the water bath until the precipitate has dissolved, and after cooling made up to 2,000 cubic centimeters. One cubic centimeter of this reagent contains 2 mg. of copper. It is said to be of a constant and stable composition.—(D. Zuckerindustrie, 1889, No. 14.)

E. Preuss (D. Zuckerindustrie, 1889, p. 1419; Zeitschr., 40, 118) notes the following concerning the quantitative determination of invert sugar with Soldaini's solution:

"In an earlier discussion on the reducing power of invert sugar I pointed out the necessity, in determining it with Soldaini's reagent, of always using a reducing liquid of constant composition; that is, having a certain percentage of copper and degree of alkalinity. The method of preparation outlined by me has now been so much improved by Scheller and Striegler that a solution is obtained by their process which seems to be well adapted for quantitative purposes. Scheller's method recommends itself by its simplicity. It consists in adding 15.8 grams copper sulphate to a hot solution of 594 grams potassium bicarbonate, and making up to 2,000 cubic centimeters, when the precipitate has been dissolved. Three solutions prepared in this manner showed the same specific gravity, 1.1789, a similar reducing power with regard to invert sugar solutions, and were very stable. As it is to be expected that the advantages which Soldaini's reagent possesses over Fehling's solution will cause its general adoption for the quantitative estimation of invert sugar, it will be of value to determine the exact reducing power of invert sugar with regard to this solution, especially as experiments so far made show it to be not exactly proportional to the quantity of invert sugar used. In the experiments described below I used Soxhlet's 1 per cent invert sugar solution, and made the reduction by heating 150 cubic centimeters of the copper solution by the direct flame and adding the invert sugar solution from a pipette.

"Upon boiling five minutes, 50 mg. invert sugar precipitated on an average 138 mg. copper; upon boiling ten minutes, 156 mg. copper; upon boiling fifteen minutes, 162 mg. copper; 75 mg. invert sugar on boiling five minutes, 190 mg. copper; 75 mg. invert sugar on boiling ten minutes, 215 mg. copper; 75 mg. invert sugar on boiling fifteen minutes, 231 mg. copper; 25 mg. invert sugar on boiling five minutes, 72 mg. copper; 25 mg. invert sugar on boiling ten minutes, 83 mg. copper; 25 mg. invert sugar on boiling fifteen minutes, 93 mg. copper; 40 mg. invert sugar on boiling five minutes, 112 mg. copper; 40 mg. invert sugar on boiling ten minutes, 127 mg. copper; 40 mg. invert sugar on boiling fifteen minutes, 138 mg. copper.

"This shows that a definite time of boiling must be observed in using Soldaini's reagent for quantitative determinations. As the separation of copper increases up to fifteen minutes boiling, and on the other hand such long boiling would render the

analysis cumbersome and the solution of copper suboxide possible, ten minutes were taken as the basis for the determination of the curve of reduction. Under these conditions

	Average.
I. 5 mg. invert sugar reduced..	19 mg. Cu.
II. 10 mg. invert sugar reduced..	34 mg. Cu.
III. 25 mg. invert sugar reduced..	83 mg. Cu.
IV. 40 mg. invert sugar reduced..	128 mg. Cu.
V. 50 mg. invert sugar reduced..	157 mg. Cu.
VI. 60 mg. invert sugar reduced..	184 mg. Cu.
VII. 70 mg. invert sugar reduced..	214 mg. Cu.

"Using these values the following proportion is calculated for the curve of reduction by the method of the least squares :

$$y = 2.2869 + 3.299 x - 0.004101 x_2,$$

where x represents the mg. invert sugar used, and y the corresponding amount of copper. By solving the quadratic equation the invert sugar can easily be calculated from the copper found. The following table has been prepared to facilitate this :

Mg. invert sugar.	Mg. cu.	Mg. invert sugar.	Mg. cu.	Mg. invert sugar.	Mg. cu.	Mg. invert sugar.	Mg. cu.
5	18.8	18	60.3	31	100.6	44	139.5
6	21.9	19	63.5	32	103.6	45	142.4
7	25.2	20	66.6	33	106.6	46	145.4
8	28.4	21	69.7	34	109.7	47	148.3
9	31.6	22	72.9	35	112.7	48	151.2
10	34.9	23	76.0	36	115.7	49	154.1
11	38.1	24	79.1	37	118.7	50	157.0
12	41.3	25	82.2	38	121.8	51	171.3
13	44.5	26	85.3	39	124.8	52	185.5
14	47.7	27	88.5	40	127.8	53	200.4
15	50.9	28	91.4	41	130.7	54	213.1
16	54.0	29	94.5	42	133.6	55	226.6
17	57.2	30	97.6	43	136.5	56	240.0

"The values of the table correspond satisfactorily to the quantities of copper found experimentally, as the following shows :

Mg. invert sugar.	Mg. copper.	
	<i>Calculated.</i>	<i>By experiment.</i>
5	18.8	19
10	34.9	34
25	82.2	83
40	127.8	128
50	157.0	157
60	185.5	184
70	213.1	214

In carrying out the estimations of invert sugar by Soldaini's reagent, we should closely follow the method of manipulation laid down, using for reduction an amount of polarized filtrate corresponding to 10 grams of substance. The filtration must not be too slow, and too great a dilution must be avoided, so that no subsequent formation of copper oxyhydrate or cuprous oxide takes place."

EXAMINATION OF SOME TABLE SIRUPS.*

The experimental station of the Austro-Hungarian Centralverein obtained several imported and a high grade domestic table sirup, and had them examined by the

* F. Strohmer, Oestreich, Zeitscher, 1888, 6.

methods elaborated by Herzfeldt and his followers, so as to obtain some knowledge concerning their nature. The following results were obtained :

	Imported table sirups.				Domestic sirup.
	I.	II.	III.	IV.	V.
Specific gravity at 17.5° C.....	1.4233	1.4173	1.4344	1.4309	1.4181
Degree Balling.....	81.10	80.22	82.74	82.23	80.33
Direct polarization.....	39.50	37.80	36.05	32.90	52.50
Polarization at 20° C. after inversion.....	16.10	17.0	16.50	16.60	17.10
Reducing sugar determined as invert sugar, according to Preuss.....	25.50	21.56	28.34	21.67	0.47
Total solids*.....	74.13	71.04	74.03	74.28	77.55
Ash.....	3.75	5.07	4.68	6.94	9.74

* By drying with sand at 100° C. in a vacuum.

† Sulphates after deducting one-tenth.

The following composition is calculated for the sirups from these analyses :

	I.	II.	III.	IV.	V.
Water.....	25.87	28.96	25.97	25.72	22.45
Cane sugar (Clerget).....	41.91	41.31	39.60	37.30	52.45
Invert sugar.....	7.09	10.32	10.44	12.94	0.47
Optically inactive sugar.....	18.41	11.24	17.90	8.73	0.00
Ash.....	3.75	5.07	4.68	6.94	9.74
Organic matter not sugar, by difference.....	2.97	3.10	1.41	8.37	14.89
	100.00	100.00	100.00	100.00	100.00

Optically inactive sugar in this case is a mixture of glucose and invert sugar, in which the right-handed rotation of one is exactly equal to the left-handed rotation of the other. These analyses show that the domestic sirup is nothing more than a beet-sugar molasses, while the imported sirups are a better grade of colonial cane-sugar molasses. The taste and general appearance of the imported sirups showed them to be colonial molasses, while the domestic table sirup did not taste much better than common molasses.

On motion, the convention adjourned until Saturday morning at 9.30 o'clock.

THIRD DAY.

MORNING SESSION, SATURDAY.

The convention was called to order by the president at 9.30 o'clock.

Mr. Wiley said that at the time of adjournment on the preceding day he had finished the reading of his report upon sugar.

Mr. Caldwell moved that the methods for analysis of sugar products proposed by Mr. Wiley be adopted as the official methods for the coming year. Carried.

Mr. Myers presented the following report :

MR. PRESIDENT: Your committee, appointed to consider and report upon the recommendations of our president in his address, beg leave to submit that they have carefully considered the recommendations made by him, and would respectfully recommend that—

First. We adopt potassium tetra-oxalate for the manufacture of the standard acid solution. (Referred to reporter on nitrogen.)

Second. (Consideration postponed.)

That in the determination of the citrate-soluble phosphoric acid all analysts be urged to adhere strictly to the scheme of analysis as to temperature, time, and manner of digestion, and that the filter pump be used in filtering.

REPORTERS ON FOODS AND FEEDING STUFFS.

Third. That the work of the reporters on "cattle foods," as now constituted, be divided, and that two reporters be appointed, one of whom shall consider methods of analysis, etc., relating to fodders, oil cake, and feed stuffs; the other to consider grains, mill products, and articles of human food not embraced under the work of other reporters already agreed upon.

Fourth. That a reporter be appointed to consider methods of ash analyses and soil analyses.

All of which is respectfully submitted by your committee.

JOHN A. MYERS,
R. C. KEDZIE,
H. W. WILEY.

Mr. Wiley moved that the report be accepted. Carried.

Mr. Wiley moved that discussion upon the recommendation in reference to phosphoric acid be postponed until the report of Mr. Burney upon that subject should be before the association. Carried.

By request of the president, Mr. Myers again read the first recommendation.

The president asked whether it was proposed to adopt potassium tetra-oxalate alone as a standardizer in testing the acid solution.

Mr. Myers said that such was the intention; it was to be taken as the standard.

Mr. Wiley said that this could not now be done without a reconsideration of the work already gone over. He moved that the recommendation in question be referred to the reporter on nitrogen, to be reported upon next year. Carried.

Mr. Myers again read the third recommendation.

Mr. Voorhees moved that the recommendation be adopted. Seconded.

Mr. Wiley moved that the recommendation be amended by striking out the words "reporter on cattle foods," and substituting in place thereof the words *reporters on foods and feeding stuffs*. He thought that the association was not warranted in distinguishing between human food and the food of other animals. The change suggested being made, he would be perfectly satisfied with the proposed division of labor between the reporters.

The motion was carried.

Mr. Huston said that the recommendation referred to a division of work already agreed upon. It was not clear to all what things each of the two reporters should handle, and some information ought to be given upon that point before the matter was passed.

Mr. Farrington suggested that a division might be made by separat-

ing the concentrated and coarse fodders, calling meal and oil cakes concentrated fodders, and hay, etc., coarse fodders.

Mr. Huston moved, as an amendment to the original motion, that the two reporters to be appointed should agree upon the division, their decision to be reported in the proceedings.

Mr. Caldwell said that the division would probably be determined by the methods of analysis. There were two classes of concentrated feeding stuffs, the milling product and the oil meals. As he understood, the proposed change was suggested by the large amount of farinaceous matter in food products, which required a somewhat different method of treatment. He did not quite like the classification contemplated; it did not divide the work equally, but gave to one reporter a very large amount of work, and left only the coarse fodders, straw, hay, etc., to the other. It might be better to include the oil meals and coarse fodders under one head and the grains and milling products under the other.

The president said that he understood that to be the recommendation of the committee in the original resolution.

Mr. Wiley said that Mr. Caldwell had expressed his own idea as to the division, that the starchy foods should go to one reporter and the foods in which the so-called nitrogen-free extract or other substances than starch formed the greater part of the digestible material should go to the other. The reporters could easily divide the stuffs by separating the starchy and non-starchy foods.

Mr. Myers said that the committee had the same idea. The process of fodder analysis made no provision for dealing with the difficulties arising from the presence of large amounts of starch in some of the materials, and the committee believed that the work should be divided in the manner stated by Messrs. Caldwell and Wiley.

Mr. Huston withdrew his proposed amendment, and the recommendation, as amended, was adopted.

Mr. Myers again read the fourth recommendation, and on motion of Mr. Caldwell the same was adopted.

The president stated that the business meeting of the association was now in order, and that the first business would be the election of officers for the ensuing year; he stated the qualifications of voters, as prescribed by the constitution, and appointed Mr. Voorhees as teller.

The following officers were elected by ballot:

President, Mr. G. C. Caldwell.

Vice-president, Mr. N. T. Lupton.

Secretary, Mr. H. W. Wiley.

Executive committee, Messrs. E. B. Voorhees and R. C. Kedzie.

Mr. Kedzie offered the following resolution:

Resolved, That the thanks of this association be tendered to the Smithsonian Institution for the use of this hall, and to the Department of Agriculture for the courtesies extended to this association, and the cordial interest shown in our transactions.

The resolution was adopted.

Mr. Robinson offered certain resolutions, which, after some discussion and amendment, were adopted in the following form :

Resolved, That a committee of three, of which Mr. Wiley shall be chairman, and the remaining members shall be named by the president of the association, be appointed to inquire into the desirability and feasibility of establishing a chemical laboratory at the Columbian Exposition to be held in Chicago in 1893, and to report at the next meeting of the association.

The president appointed as such committee Messrs. Wiley, Atwater, and Robinson.

Mr. Bowman offered the following resolution :

Resolved, That the reporters on the different subjects, such as potash, nitrogen, etc., be instructed to prepare an abstract of the changes made in the methods of analysis, and transmit a copy of the same to each member of the association as soon as possible after adjournment.

Mr. Atwater said that if the reporters would furnish him with brief abstracts of the changes made he would insert them in the coming number of the Experiment Station Record, which was nearly ready for the press.

The resolution was adopted.

The president said that Mr. de Ghequier, representing the German Potash Works, was present, and extended to the association an invitation to visit his office and examine the plans, photographs, etc., there exhibited, illustrating the work carried on by his company. He called upon Mr. de Ghequier to make a few remarks.

Mr. de Ghequier said that he felt under great obligation in being permitted to address the association, he being in no way connected with official chemical work. The work of the association was watched with keen interest from the other side of the water. He was especially indebted to Mr. Atwater, whose published writings contained the first impulse toward the now extensive use of potash salts in this country. In one of the first documents issued by the Office of Experiment Stations Mr. Atwater had stated that the difficulties of the newer stations were enhanced by the fact that nearly all the accumulated experience in regard to the subjects with which they had to deal was recorded only in foreign literature, and was, therefore, accessible only to a few, and had urged as a most important work the compilation of the main results of research in various special lines, to be published in forms conveniently suited to the use of American investigators. Acting upon this suggestion, the German Potash Works had intrusted to the speaker the compilation of results obtained in experimentation with potash salts. This compilation had been made and was submitted to Professor Wagner and other noted chemists before translation and publication in America. It was issued in pamphlet form and had been widely circulated, its main object being to acquaint the public with the new position which the potash question had assumed in agricultural economy. Germany consumed in 1885 only 50,870 tons of kainit, while in the past year upwards

of 150,000 tons were required to supply the demand. These facts would serve to illustrate the practical results of rational application of potash salts in Germany.

The whole district north of Berlin had formerly been characterized by a sandy soil upon which grass would hardly grow, but was now covered with thriving orchards of peaches and other fruits. The change for the better had resulted from the application of potash salts, not alone, of course, but in combination with other fertilizing substances in which the soil may have been deficient. The conclusions to be drawn from these results seemed irresistible, and the German Potash Works had determined to present the facts to the United States so that the progressive spirit of this country might be prompted to investigate them and to ascertain to what extent the same means could be employed to produce similar effects in certain sections here. From what had already been done it seemed reasonable to believe that large areas of exhausted soils could be greatly benefitted by the application of these salts, which were not needed at all by rich soils not yet worked out. A scientific question in connection with the subject was met with in the influence exerted by potash salts upon plant growth. It had been found in Germany that by increasing the proportion of potash in fertilizers the plant became more apt to utilize the nitrogen and phosphoric acid inherent in the soil or furnished to it by artificial cultivation. The question thus raised was admitted to be important by Professor Wagner himself, who had declared his own inability to fully answer it without further study and research.

The mission intrusted to the speaker, he did not hesitate to say, had for its superior object the increase of consumption of potash salts in this country; but the German Potash Works stood upon the ground that this desired increase should not be brought about by advertisements soliciting the purchase of their products, but solely by their own merits as they should commend themselves, after experiment, to the agricultural colleges and experiment stations. This seemed to be the proper course, it being considered that none had the prosperity and advancement of agriculture nearer at heart than this association and the Association of American Agricultural Colleges and Experiment Stations, which would meet in November. Perhaps no words could more eloquently express the appreciation with which the German Potash Works regarded the efforts of these associations than the words used by Mr. Atwater on the excursion yesterday, to wit, that their progress, the decided improvement in their work, the enlargement of their scope, and the great interest and earnestness with which all workers had taken up their several lines of study and experiment rendered them the most important associations existing in the United States for the future prosperity of agricultural interests.

Mr. de Ghequier thanked the association for the time extended to him, and renewed the invitation to visit the Washington office of the

German Potash Works and inspect the maps, plans, and photographs there on exhibition.

Mr. Burney presented the following:

REPORT ON PHOSPHORIC ACID.

By W. B. BURNEY.

Adopting the usual method of reporting on phosphoric acid, the subject will be presented in the following order: (1) Condensed abstracts of methods published during the year; (2) results of work done by members of the association and others; (3) recommendations for the next year.

ABSTRACTS.*

THE ESTIMATION OF PHOSPHORIC ACID BY AMMONIUM MOLYBDATE.†

For the titration of phosphoric acid by molybdate, the latter should be acidified with three to four molecular proportions of nitric acid to one of molybdic acid, while the phosphate solution is only slightly acidified. Under these conditions one molecular proportion of phosphoric anhydride is exactly precipitated by twenty-four of MoO_3 . Ten grams of molybdic acid (or 12.262 grams of crystallized hexammonium heptamolybdate) is dissolved in an excess of dilute ammonia, the solution neutralized, further acidified with 15 grams nitric acid, and diluted to 1 liter. 24.3 to 24.5 cubic centimeters precipitate 0.01 gram P_2O_5 .

For gravimetric determinations the author considers Finkener's method the best. The washed precipitate is dissolved in warm dilute ammonia, the solution evaporated until most of the ammonia is expelled, then mixed with an excess of nitric acid, evaporated and heated to complete decomposition of the ammonium nitrate, the final temperature being about 180° . The residue contains 3.753 per cent. P_2O_5 .

If the precipitate has been washed with neutral ammonium nitrate, it may be titrated as follows: It is stirred up with cold water containing phenolphthalein and mixed with standard soda until it has completely dissolved and the liquid is red. It is then rapidly titrated back with nitric acid. One cubic centimeter $\frac{N}{10}$ soda = 0.00061739 gram P_2O_5 .

ANALYSIS OF CONCENTRATED SUPERPHOSPHATES.‡

This superphosphate generally has from 4 to 5 per cent of P_2O_5 as ferric or aluminic phosphate which is insoluble in water but soluble in concentrated solutions of superphosphate. It is therefore important to use sufficient water in the first extraction, otherwise the soluble P_2O_5 will be reported too high. Take 1.5 grams of the superphosphate, place in a beaker and add a little water to soften and break up the lumps. Then make up to 90 cubic centimeters. Allow it to stand five minutes and filter off the supernatant liquid. To the residue add 90 cubic centimeters of water, stir, allow it to settle and filter. Treat the residue with 60 cubic centimeters of water, warm gently, bring upon the filter, and wash once with hot water.

CITRATE METHOD, PHOSPHORIC ACID DETERMINATION.§

The author supposes that the double phosphates with ammonium form soluble compounds with ammonium citrate, and that only the magnesium-ammonium phosphate

* These abstracts were prepared by Mr. W. H. Krug, of the Chemical Division, Department of Agriculture.

† Hundeshagen, Fres.: *Zeitsch. f. anal. Chem.*, 28, 165-172.

‡ Hughes, J.: *Chem. News*, 60, 91.

§ Reitmar, O.: *Zeitsch. f. angew. Chem.*, 1889, 702-9, and 1890, 19-25.

is easily but never completely decomposed. To make this as complete as possible, more magnesium chloride than can combine with the ammonium citrate to form $\text{MgNH}_4\text{C}_6\text{H}_5\text{O}_7$ should be present so that this excess may act upon the compound $\text{MgNH}_4\text{PO}_4 + (\text{NH}_4)_3\text{C}_6\text{H}_5\text{O}_7$ which may have formed. Some MgNH_4PO_4 , however, always remains in solution and causes a loss. When other bases (CaO , Fe_2O_3 , Al_2O_3 , MnO , FeO) are present, their phosphates are somewhat thrown down and cause an error. With CaO the error is largest. If the lime has been removed by oxalate or sulphuric acid, a loss of P_2O_5 may always be expected if we do not use at least twice the amount of magnesia mixture usually prescribed. Silica always contaminates the precipitate when present. The author considers the molybdenum method more accurate.

In addition to the above article the author notes the following: *

(1) Treatment of the substance with hydrochloric acid is objectionable, as the precipitate may contain considerable silica.

(2) Treatment with sulphuric acid reduces this error to about 1 mg. of silica.

(3) Even when an excess of ammonium citrate is present and only little CaO as pyrophosphate.

(4) The presence of manganese exerts a similar influence.

(5) The error caused by Fe_2O_3 and Al_2O_3 in a sulphuric acid solution is very slight when little silica is present, even when large amounts of these oxides are present; they delay precipitation however.

(6) Small quantities of $\text{Mg}(\text{OH})_2$ are always present; this error is slightest when the separation is made in a solution containing 2.5 per cent ammonia. In a nearly neutral solution and in the presence of alkaline salts the error is greatest.

(7) The phosphoric acid is always incompletely precipitated.

(8) In making a control-analysis by the molybdate method, the method of treating substances rich in silica must be regarded.

The average error according to the author is $\pm .128$ per cent, the — result where only small quantities of P_2O_5 are present.

With Thomas-slugs and raw phosphates, the results are always too high.

THE USE OF PHOSPHORIC ACID OF ANIMAL OR MINERAL ORIGIN IN THE CULTIVATION OF THE SUGAR BEET.†

The results showed that no difference exists between the superphosphates of either animal or mineral origin.

ESTIMATION OF PHOSPHORIC ACID IN SLAGS. FORMATION OF TETRAHYDRATED FERRIC PHOSPHATE.‡

In eliminating by means of nitric acid the residual hydrochloric acid from slag, which had been treated with the latter reagent to remove silica, a probable source of error is shown by the author, in that a tetrahydrated ferric phosphate, $\text{Fe}_2(\text{PO}_4)_2 + 4 \text{H}_2\text{O}$, is precipitated as a yellow granular powder. This differs from the normal ferric phosphate resulting from the precipitation of a ferric salt by disodium phosphate in not suffering dehydration at 110° .

ESTIMATION OF PHOSPHORIC ACID IN THE PRESENCE OF SILICA.§

The author proves by numerous experiments that phosphoric acid may be estimated in the presence of pretty large quantities of silica (solution of soluble glass acidified

* Reitmar, O.: Zeitsch. f. angew. Chem., 90, 196–210.

† Stoklasa, J.: Böhm. Zeitsch. f. Zuckerindustrie. 14, 137–142; Chem. Centralbl., 1890, I, 771.

‡ Arth, G.: Bull. Soc. Chim, (3) 2, 324–327; J. Chem. Soc., March, 1890, 292.

§ Preis, K.: Listy Chem., 13, 153, 154; J. Chem. Soc., July, 1890, 825.

with hydrochloric acid was employed) when the precipitate of ammonium phosphomolybdate is washed with pure cold water. As the liquid runs through the filter turbid at the end, double filters should be used.

RESULTS OF WORK DONE DURING THE YEAR.

In answer to a circular letter sent out in the spring, forty-four replies were received, and thirty-seven chemists consented to participate in the work on phosphoric acid. It is to be regretted that many of these have failed to analyze the samples sent them. Early in May three samples were sent to each chemist consenting to do the work, and consisted as follows:

No. 1. A superphosphate.

No. 2. A complete fertilizer.

No. 3. A complete fertilizer containing cotton-seed meal and other substances difficult to oxidize.

These samples were prepared with the utmost care, and no pains were spared to insure absolute uniformity in the materials submitted for examination. The fertilizers had probably been made many months when they were collected for this work. They were first air-dried in thin layers for several days, and after grinding were passed through a sieve of forty meshes to the linear inch; the samples then stood for several days more and were again mixed, first, in large jars, then by passing through a coarser sieve, and finally by hand on heavy paper, after which they were rapidly bottled and sealed.

From the specimens herewith submitted you may judge of the thoroughness of this work. It does not appear probable, therefore, that the differences in the analytical results presented in the following tables can be attributed to any lack of uniformity in the samples or to any dereliction on the part of your reporter. The results are tabulated in the order in which they were received, and are as follows:

No. 1.—*Superphosphate.*

	H ₂ O.	Soluble P ₂ O ₅ .	Re- verted P ₂ O ₅ .	Avail- able P ₂ O ₅ .	Insolu- ble P ₂ O ₅ .	Manip- ulation.	Total P ₂ O ₅ .
H. J. Patterson, experiment station, Maryland.....	6.10	9.18	3.72	12.90	4.42	h-l&c-p	¹ 17.32
E. H. Farrington, experiment station, Illinois.....	6.42	9.16	3.37	12.53	5.00	hb-l-f	² 17.53
C. L. Parsons, experiment station, New Hampshire.....	6.17	9.19	3.22	12.41	4.80	b-c-f	¹ 17.21
F. W. Morse, experiment station, New Hampshire.....	5.99	8.98	2.95	11.93	5.09	b-c-f	¹ 17.02
W. Wipprecht, experiment station Texas.....	³ 6.18	9.16	4.10	13.26	5.04	h-l-p	¹ 18.30
D. O'Brine, experiment station, Colo- rado.....	7.07	9.29	2.13	11.42	5.83	h-l-p	¹ & ² 17.25
Shepard Laboratory, Charleston, S. C B. F. Finney, Department of Agricul- ture, Virginia.....	5.63	9.02	4.32	13.34	4.19	h-cl-p	¹ 17.53
R. H. Gaines, Department of Agricul- ture, Virginia.....	5.06	9.81	3.04	12.85	5.42	h-l-p	¹ 18.27
Walker Bowman, experiment station, Virginia.....	5.42	9.59	3.11	12.70	5.34	h-l-p	¹ 18.04
J. A. Fries, Pennsylvania State College H. B. McDonnell, Pennsylvania State College.....	5.87	9.58	3.32	12.90	4.80	h-c-p	¹ 17.70
J. L. Hills, experiment station, Ver- mont.....	5.93	{ ⁴ 9.48 ⁵ 9.48}	3.92	13.40	{ ⁴ 4.63 ⁵ 4.80}	.....	18.03
H. B. McDonnell, Pennsylvania State College.....	6.11	{ ⁴ 9.77 ⁵ 9.86}	3.11	12.88	{ ⁴ 5.00 ⁵ 4.99}	.....	17.88
J. L. Hills, experiment station, Ver- mont.....	5.82	9.22	3.52	12.74	4.60	b-l-f	² 17.34
B. O. White, experiment station, Ver- mont.....	.....	8.97	4.05	13.02	4.35	b-l-f	² 17.37
F. B. Carpenter, experiment station, North Carolina.....	.....	9.31	3.85	13.16	⁷ 4.23	b-l-p	⁹ 1, & ² 17.39
B. W. Kilgore, experiment station, North Carolina.....	.....	9.39	3.25	12.64	⁸ 4.77	b-l-p	17.41
Aug. E. Knorr, United States Depart- ment of Agriculture.....	6.01	9.34	3.53	12.87	4.46	h-c-f	² 17.33
A. L. Winton, R. S. Curtiss, experi- ment station, Connecticut.....	5.91	9.27	3.91	13.18	4.21	b-l-p	¹⁰ 17.39
H. R. Baldwin, experiment station, West Virginia.....	.....	9.02	3.22	12.24	4.72	b-c-f	16.96
R. C. Kedzie, experiment station, Michigan.....	⁶ 9.65	8.77	3.86	12.63	4.56	b-c	17.19
F. S. Shiver, Department of Agricul- ture, South Carolina.....	.....	8.90	4.66	13.56	4.22	b-c-f	¹ 17.78
Average.....	6.21	9.26	.....	.....	4.75	.....	17.54

¹ HNO₃ + HCl.² HCl + KClO₃.³ 98° C.⁴ Official method.⁵ Washed directly on filter.⁶ Dried in H at about 100°C.⁷ Solution in HNO₃.⁸ Solution in HCl.⁹ Mg (NO₃)₂ method.¹⁰ HCl.

No. 2.—Complete fertilizer.

	H ₂ O.	Soluble P ₂ O ₅ .	Re- verted P ₂ O ₅ .	Avail- able P ₂ O ₅ .	Insol- uble P ₂ O ₅ .	Manip- ulation.	Total P ₂ O ₅ .
H. J. Patterson, experiment station, Maryland	9.27	6.52	3.81	10.33	0.87	h-l & c-p	¹ 11.20
E. H. Farrington, experiment station, Illinois	10.61	6.12	3.65	9.77	1.43	h(b)-l-f	² 11.20
C. L. Parsons, experiment station, New Hampshire	9.67	6.26	3.66	9.92	1.35	b-c-f	¹ 11.27
F. W. Morse, experiment station, New Hampshire	9.59	6.29	3.71	10.00	1.39	b-c-f	¹ 11.39
W. Wipprecht, experiment station, Texas	³ 9.71	5.80	4.29	10.09	1.26	h-l-p	11.35
S. T. Donaldson, Charleston, S. C.		6.03	4.34	10.37	1.07	f	¹¹ 11.44
D. O'Brine, experiment station, Colo- rado	9.97	6.59	2.92	9.51	1.55	h-l-p	¹ & ² 11.06
Shepard Laboratory, Charleston, S. C. .	8.55	6.21	4.22	10.43	1.15	h-c-l-p	¹ 11.58
B. F. Finney, Department of Agricul- ture, Virginia	7.50	6.87	3.22	10.09	2.00	h-l-p	¹ 12.09
R. H. Gaines, Department of Agricul- ture, Virginia	7.44	6.72	3.25	9.97	2.15	h-l-p	¹ 12.12
Walker Bowman, experiment station, Virginia	8.31	6.78	3.12	9.90	1.50	h-c-p	¹ 11.40
J. A. Fries, Pennsylvania State Col- lege	8.60	{ ⁴ 6.65 ⁴ 6.60}	4.01	10.66	{ ⁴ 1.10 ⁵ 1.23}	.....	11.76
H. B. McDonnell, Pennsylvania State College	9.10	{ ⁴ 6.72 ⁵ 6.66}	3.66	10.38	{ ⁴ 1.29 ⁵ 1.24}	.....	11.67
J. L. Hills, experiment station, Ver- mont	9.25	6.54	3.29	9.83	1.27	b-l-f	⁹ 11.10
B. O. White, experiment station, Ver- mont		6.40	3.33	9.73	1.23	b-l-f	⁹ 10.96
F. B. Carpenter, experiment station, North Carolina		6.61	3.68	10.29	⁷ 1.05	b-l-p	^{1,2} & ⁹ 11.34
B. W. Kilgore, experiment station, North Carolina		6.74	3.52	10.26	⁸ 1.05	b-l-p	^{1,2} & ⁹ 11.31
Aug. E. Knorr, United States Depart- ment of Agriculture	10.45	6.85	3.41	10.26	1.17	h-c-f	⁹ 11.43
A. L. Winton, R. S. Curtiss, Connecti- cut Agricultural Experiment Sta- tion	9.32	6.57	3.57	10.14	1.15	b-l-p	⁹ 11.29
H. R. Baldwin, experiment station, West Virginia		6.57	3.38	9.95	1.13	b-c-f	11.08
R. C. Kedzie, experiment station, Michigan	⁹ 12.55	5.97	4.15	10.12	1.16	b-c	11.28
F. S. Shiver, Department of Agricul- ture, South Carolina		6.27	3.99	10.26	1.20	b-c-f	¹⁰ 11.46
Average	9.37	6.46	.....	.....	1.30	.....	11.40

b Balance.
c Coralline.
l Litmus.
f Filter.
p Pump.

¹ HNO₃+HCl.
² HCl+KClO₃.
³ 98° C.
⁴ Official method.
⁵ Washed directly on filter.
⁶ Dried in H at about 100° C.

⁷ Solution in HNO₃.
⁸ Solution in HCl.
⁹ Mg(NO₃)₂ method.
¹⁰ Solution in H₂SO₄+KNO₃.
¹¹ Ignited.

No. 3.—Complete fertilizer, containing cotton-seed meal.

	H ₂ O.	Soluble P ₂ O ₅ .	Re- verted P ₂ O ₅ .	Avail- able P ₂ O ₅ .	Insol- uble P ₂ O ₅ .	Manip- ulation.	Total P ₂ O ₅ .
H. J. Patterson, experiment station, Maryland	5.45	6.32	2.77	9.09	2.68	h-l-c-p	¹ 11.77
E. H. Farrington, experiment station, Illinois	8.10	6.12	2.51	8.63	3.27	h-b-l-f	² 11.90
C. L. Parsons, experiment station, New Hampshire	5.56	6.35	2.61	8.93	2.88	b-c-f	¹ 11.84
F. W. Morse, experiment station, New Hampshire	5.38	6.47	2.36	8.83	3.26	b-c-f	¹ 12.09
W. P. Frost, Savannah, Ga.		6.41	3.13	9.54	2.70		³ 12.24
S. T. Donaldson, Charleston, S. C.		5.83	3.96	9.79	2.58	f	³ 12.37
D. O'Brine, experiment station, Colo- rado	7.96	6.55	0.65	7.20	4.37	h-l-p	¹ & ² 11.57
F. B. Dancy, Raleigh, N. C.				9.44	2.66		³ 12.10
Shepard Laboratory, Charleston, S. C.	5.30	6.21	2.87	9.08	2.76	h-c-l-p	¹ 11.84
B. F. Finney, Department of Agricul- ture, Virginia	4.42	7.01	2.86	9.87	3.53	h-l-p	¹ 13.40
R. H. Gaines, Department of Agricul- ture, Virginia	4.38	6.65	2.91	9.56	3.49	h-l-p	¹ 13.05
Walker Bowman, experiment station, Virginia	5.26	6.57	2.56	9.13	2.98	h-c-p	¹ 12.11
J. A. Fries, Pennsylvania State Col- lege	5.48	{ ⁴ 6.56 ⁴ 6.55}	{3.06}	9.62	{ ⁶ 42.80 ⁶ 42.80}	{-----}	12.42
H. B. McDonnell, Pennsylvania State College	5.81	{ ⁴ 6.81 ⁴ 6.89}	{2.28}	9.09	{ ⁶ 43.03 ⁶ 43.12}	{-----}	12.12
J. L. Hills, experiment station, Ver- mont	4.99	6.32	2.98	9.30	2.92	b-l-f	³ 12.22
B. O. White, experiment station, Ver- mont		6.27	3.15	9.42	2.90	b-l-f	³ 12.32
F. B. Carpenter, experiment station, North Carolina		6.40	2.72	9.12	⁶ 2.73	b-l-p	^{1,2} & ³ 11.85
B. W. Kilgore, experiment station, North Carolina		6.62	2.72	9.34	⁷ 2.90	b-l-p	^{1,2} & ³ 12.24
Aug. E. Knorr, United States Depart- ment of Agriculture	7.08	6.67	3.25	9.92	2.66	h-c-f	³ 12.58
A. L. Winton, R. S. Curtiss, Connecti- cut Agricultural Experiment Station	5.57	6.46	3.13	9.59	2.78	b-l-p	³ 12.37
H. R. Baldwin, experiment station, West Virginia		6.50	3.42	9.92	2.31	b-c-f	12.23
R. C. Kedzie, experiment station, Michigan	⁸ 11.47	5.97	3.12	9.09	2.77	b-c	11.86
F. S. Shiver, Department of Agricul- ture, South Carolina		6.16	3.46	9.62	2.78	b-c-f	12.40
Average	6.15	6.42	-----	-----	2.94	-----	12.21

b Balance.
c Coralline.
f Filter.
l Litmus.
p Pump.

¹ HNO₃ + HCl.
² HCl + KClO₃.
³ Mg (NO₃)₂ method.
⁴ Official method.
⁵ Washed directly on filter.

⁶ Solution in HNO₃.
⁷ Solution in HCl.
⁸ Dried in H at about 100° C.
⁹ Ignited.

Averages.

	No. of determi- nations.	Average.	Highest.	Lowest.	Differ- ence.
Sample No. 1:					
Moisture	16	6.21	9.65	5.06	4.59
Soluble phosphoric acid	21	-----	9.81	8.77	1.04
Insoluble do.	21	-----	5.83	4.19	1.64
Total do.	21	17.54	18.30	16.96	1.34
Sample No. 2:					
Moisture	16	-----	12.55	7.44	5.11
Soluble phosphoric acid	22	-----	6.87	5.80	1.07
Insoluble do.	22	-----	2.15	0.87	1.28
Total do.	22	-----	12.12	10.96	1.16
Sample No. 3:					
Moisture	15	-----	11.47	4.38	7.09
Soluble phosphoric acid	22	-----	7.01	5.83	1.18
Insoluble do.	23	-----	4.37	2.31	2.06
Total do.	23	-----	13.40	11.57	1.83

No. 1.—Total P_2O_5 .

	Mg (NO ₃) ₂ .	HNO ₃ +HCl.	HCl+ KClO ₃ .	Ignition and HCl.	Ignition and HNO ₃ .	H ₂ SO ₄ + KNO ₃ .
B. W. Kilgore, North Carolina	17.42 (HCl) ..	17.51	17.30	17.40	.....	.....
F. B. Carpenter, North Carolina.....	17.35 (HNO ₃) ..	17.42	17.40	.....	17.09	.....
F. S. Shiver, South Carolina.....	.....	17.81	.....	.....	.....	17.76
A. L. Winton, Connecticut	*17.40.....	.....	.....	.....	.....	17.52

* By HCl alone.

D. O'Brine states that "No. 1 will give different results according to the time it is treated by methods 2 and 3."

No. 2.—Total P_2O_5 .

	Mg (NO ₃) ₂ .	HNO ₃ +HCl.	HCl+ KClO ₃ .	Ignition and HCl.	Ignition and HNO ₃ .	H ₂ SO ₄ + KNO ₃ .
B. W. Kilgore, North Carolina	11.39 (HCl) ..	11.39	11.23	11.23	.....	.....
F. B. Carpenter, North Carolina.....	11.28 (HNO ₃) ..	11.32	11.33	.....	11.41	.....
F. S. Shiver, South Carolina.....	.....	.....	.....	.....	.....	{ 11.51
A. L. Winton, Connecticut.....	11.29.....	.....	.....	.....	.....	{ 11.41
						11.29

No. 3.—Total P_2O_5 .

	Mg (NO ₃) ₂ .	HNO ₃ + HCl.	HCl+ KClO ₃ .	Ignition and HCl.	Ignition and HNO ₃ .	H ₂ SO ₄ + KNO ₃ .
B. W. Kilgore, North Carolina.....	12.43 (HCl) ..	12.18	12.10	12.24	.....	.....
F. B. Carpenter, North Carolina.....	12.04 (HNO ₃) ..	11.46	11.82	.....	12.06	.....
F. B. Dancy, North Carolina.....	12.10 (HNO ₃) ..	{ 11.49	11.78	{ 12.08	.....	11.69
		{ 11.56	11.74			
H. B. McDonnell, Pennsylvania.....	.....	{ *12.08	{ §12.13	.....	.....	.....
		{ *12.15				
Do.....	.....	{ †12.34	.....	.....	.....	.....
Do.....	.....	{ †12.23	.....	.....	.....	.....
Do.....	.....	{ †12.00	.....	.....	.....	.....
		{ †12.08	.....	.....	12.16	.....
C. L. Parsons, New Hampshire.....	.....	{ 11.51	.....	12.45	.....	.....
		{ 11.48	.....	12.43	.....	.....
F. S. Shiver, South Carolina.....	.....	.....	.....	.....	.....	{ 12.43
A. L. Winton, Connecticut.....	12.37.....	.....	.....	.....	.....	{ 12.37
						12.34

* Thirty minutes.

† Mo O₃ precipitate dark.

‡ Forty-five minutes.

§ H NO₃+ KClO₃, and a little HCl after some time.

|| Seventy-five minutes.

A study of the foregoing tables reveals discrepancies alike discouraging and inexplicable. It does not appear that we have made any advance since last year. That the methods employed in these determinations are trustworthy when properly executed follows from the fact that in the hands of a few experienced analysts the results are fairly within the limits of the working error. The fault, therefore, must be ascribed to the chemist, and is doubtless due to a lack of thoroughness, to a want of scrupulous attention to minute details in the processes of solution, precipitation, filtration, washing, etc. Thus, inspecting the tables, we see results which seem to be too high through incomplete washing of the precipitate of ammonium magnesium phosphate; total phosphoric acid too low, owing to incomplete oxidation in the process of solution; insoluble phosphoric acid too high or too low, because the ammonium citrate solution was too strong or too weak, acid or alkaline, and so on.

Comment in detail upon the analytical data seems unnecessary. A very few words will suffice. In the first place, the averages are given for what they are worth, and it is not claimed nor believed that in all cases they correctly represent the percentage of phosphoric acid present in the sample. The results on moisture are noteworthy, and seem to point to some grave oversight in the execution of the official method, if indeed the method was employed in all cases. It would be interesting to know how many of the chemists actually tested the steam closet to see that the temperature approximated 100° C.

With the possible exception of the soluble, the results on phosphoric acid can not as yet be regarded as satisfactory. So long as experienced analysts differ, in extreme cases, by 0.7 to 0.8 per cent, and from the average or probable truth by 0.3 to 0.4 per cent, it must be admitted that there is room for improvement. Now, if we omit from each table three or four of the analyses which seem to be extreme, there still remain a number which differ by the amounts above mentioned. Nor is this discrepancy confined to any one kind of phosphoric acid, but it is in varying degree true of all.

In the opinion of the reporter, the remedy for all this is to be sought not so much in the improvement of the methods of analysis, as in the increased care with which the details of the methods are executed after having been once adopted by this association.

Believing that changes in the official methods should be made with the greatest caution, and only for the best of reasons, the following recommendations are suggested after much hesitation:

(1) That in the preparation of the solution of water-soluble P_2O_5 the washing be continued until the filtrate measures 300 cubic centimeters.

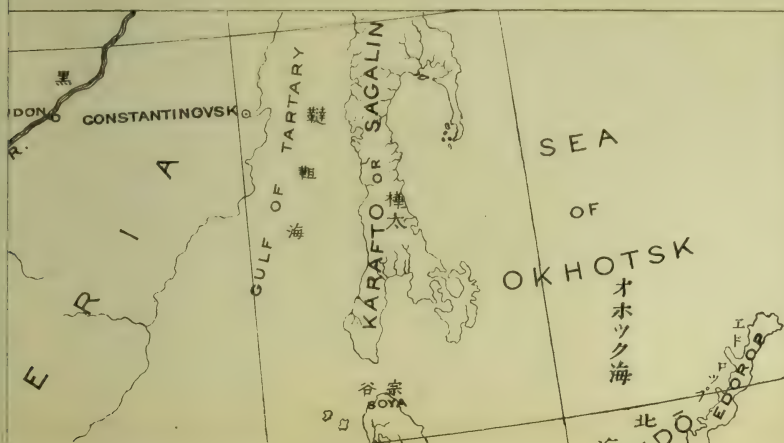
(2) That in Chemical Bulletin No. 24, page 225, the second line from top of page be changed to read as follows: Filter the warm solution quickly through a 12½ centimeter plaited filter, wash twice with half-strength ammonium citrate solution and then with water of ordinary temperature.

(3) That in all cases of fertilizers containing cotton-seed meal, the solution for total phosphoric acid be prepared by the $Mg(NO_3)_2$ method.

(4) That the association advise, in the preparation of the solution of total phosphoric acid, the use of method No. 2 (30 cubic centimeters $HNO_3 + HCl$) for superphosphates and other samples free from organic matter; and the $Mg(NO_3)_2$ method for all cases in which organic matter is present.

It is further recommended that, with these changes, the present methods of determining phosphoric acid be continued, subject, of course, to modification by the association.

Mr. Burney said that an examination of the tables would show discrepancies which in many cases were very serious. In order to show that he was in no way personally responsible for those differences he had brought with him, and now exhibited, three of the samples just as they were prepared for distribution. As stated in the report, the samples were very carefully ground, air-dried, and passed through a forty-mesh sieve; they were then allowed to stand for some days to further air-dry, after which they were passed through a coarser sieve for the purpose of intimately mixing them. They were then mixed in large jars by rapid rotation and also by hand. He had omitted no precautions in the preparation of the samples, and those now presented would speak for themselves. They were drawn many months after the manufacture of the goods, so that it might be supposed that chemical changes had ceased to take place with any degree of rapidity. After a number of analyses were received he had seen by an inspection of the results that



MAP
OF A PART OF
EASTERN ASIA
TO SHOW THE
COMMERCIAL POSITION
OF THE
PRODUCTIVE COAL FIELDS
OF
YESSO, JAPAN,

COMPILED FROM VARIOUS SOURCES
BY BENJAMIN SMITH LYMAN, CHIEF GEOLOGIST,
AND T. KADA, ASSISTANT GEOLOGIST.
17 MAY 1878.

亜細亞東部之圖

明治九年五月十七日

但シ日本蝦夷ノ豊饒ナル煤田通商上ニ係ル位置
ヲ示ス為メニ諸國ヨリ考訂編製スルモノナリ

地質學長 進士 米曼
同補 賀田 貞一

同製



SCALE: $\frac{1}{10\,000\,000}$ OF NATURE.

一分万千一之形本度尺

0 50 100 200 300 400 500 MILES

further light was needed with regard to the methods of analysis. He therefore sent out a circular letter, asking certain questions, the answers to which would be found in the tables. He had hoped that the information obtained in answer to that circular would throw some light on the analytical results, but unfortunately it had not except as to the total phosphoric acid in sample No. 3. It would be found that the various methods had given different results. As the subjects were taken up in order he would have a word to say in regard to each recommendation.

Mr. Dancy presented the following paper :

ON THE DETERMINATION OF AVAILABLE PHOSPHORIC ACID IN FERTILIZERS CONTAINING COTTON-SEED MEAL.

By F. B. DANCY, A. B.

The term *available* phosphoric acid is used to denote the difference between the *total* phosphoric acid in a fertilizer and the *insoluble*. The *total* phosphoric acid is the entire amount of phosphoric acid, of whatever kind, that the fertilizer contains. The *insoluble* phosphoric acid is, as generally accepted, that phosphoric acid which is left after 2 grams of the fertilizer, ground to pass a sieve of approximately 20 meshes to the linear inch, have had the *soluble* phosphoric acid extracted with cold water and then been digested for thirty minutes, with agitation every five minutes, at 65° C., with 100 cubic centimeters of a strictly neutral solution of ammonium citrate of a specific gravity of 1.09 immediately after which digestion they have been thoroughly washed with cold water.

The *available*, then, being the difference between the *total* and the *insoluble*, it follows that *insolubles* being equal, the *available* varies exactly and directly as the *total*, and *totals* being equal, the *available* varies exactly, though inversely, as the *insoluble*.

The *total* is a definite and fixed quantity, and there should, therefore, be no material variation in its determination between the work of accurate analysts. Not so with the others. The *soluble*, *insoluble*, *reverted*, and *available* are not fixed and definite quantities. They are dependent on so many conditions of time, temperature, degree of fineness, quality and quantity of solvent, agitation, etc., that it is no matter of wonder that even skillful manipulators vary in their determination. They are the results of methods, and will vary according to the method or the manner of executing the details of the method. But, as has been remarked and as its name implies, the *total* is *all* the phosphoric acid in the material under examination, of whatever kind and in whatever shape or form. It is not what is gotten by a method but *what there is there*, and any method, therefore, that fails to reach any part or kind of it is not a method for *total* phosphoric acid. It is sometimes said that discrimination is impracticable, and that all fertilizers should be treated equally and alike. The position is untenable. It might as well be urged that in order not to discriminate, the plain soda-lime method for the determination of nitrogen should be used on all fertilizers, those containing nitrates as well as those containing organic nitrogen alone, when every one knows that it is inadequate in the presence of nitrates. So a *total* method which is adequate for some kinds of fertilizers but not for others can not be applied to all on the above ground or any other ground, without manifest injustice to those fertilizers for which the method is inadequate.

The Association of Official Agricultural Chemists in their official methods (Bulletin 24, United States Department of Agriculture), give three alternate methods of determining *total* phosphoric acid. There is no distinction made between them, no indication that either is better adapted than the other for any particular class of fertilizers. The presumption is that they are given as interchangeable and equally allowable for all classes of fertilizers, at the pleasure or option of the operator. It is

the purpose of this article to show that one of them, at least, is entirely inadequate for fertilizers that contain cotton-seed meal, and that any chemist who uses this method on such fertilizers is in almost certain danger of doing these fertilizers a great injustice. The method referred to is the second of the three given, namely: "Solution in 30 cubic centimeters of concentrated nitric acid with a small quantity of hydrochloric acid." The writer has not extended his investigation, except imperfectly, to the other two methods. It is only with this one, as applied to cotton-seed fertilizers, that this article has to do.

Cotton-seed fertilizers are comparatively unknown in the North. It seems, therefore, that the Southern members of the Association of Official Agricultural Chemists could not have been very wide awake to the interests of a class of fertilizer manufacturers peculiar to their own section of country when they failed to have attached to this method, at the time when it was adopted by their association as one of three alternate methods, the limitation "not applicable to fertilizers containing cotton-seed meal."

Cotton-seed meal is readily and entirely soluble in either "nitric acid with a small quantity of hydrochloric acid" or in nitric acid alone. *But such a solution does not give up its phosphoric acid to molybdic solution.* It would appear that certain nitro-organic compounds are formed which prevent the phosphoric acid in the solution from being yielded up to the molybdic precipitant. Whether this is effected by in some way rendering the menstruum a solvent for the phospho-molybdate of ammonia that ought to be formed, or, by holding the phosphoric acid in check, thus preventing such a combination, is not clear. But the fact remains. The attention of the writer was first forcibly directed to it when a sample of cotton-seed meal was submitted to him for a determination of the *available* phosphoric acid it contained. A nitric acid solution of 2 grams of it was made (using also a little hydrochloric acid), the solution being perfect, and a total phosphoric acid percentage of 0.51 found. A duplicate made in the same way yielded 0.54 per cent. Being convinced that there was much more phosphoric acid in the meal than this, and recalling that a short time previously a gentleman had remarked that a friend of his had found materially more phosphoric acid in the ash of cotton-seed meal than by acid solution, 2 grams of the meal were ignited to perfect ash, the ash dissolved in acid, and a percentage of 3.24 of *total* phosphoric acid found; a duplicate in the same manner yielded 3.20, though in this case the incineration was not quite so perfect, a little char being left. The true per cent of *total* phosphoric acid in the meal then was 3.24. A solution of 2 grams made by hydrochloric acid with chlorate of potash also failed by something more than half of getting the full amount. This yielded 1.45 per cent. Next 2 grams of the meal were taken, washed with cold water in exactly the same manner as when extracting *soluble* phosphoric acid from an ordinary fertilizer, then digested with citrate solution and again washed exactly as is done in the determination of *insoluble* phosphoric acid. The residue was ignited and the phosphoric acid determined. It was found to be 0.24 per cent. So not only did a cotton-seed meal which showed only half a per cent of *total* phosphoric acid to a nitric acid solution contain in reality $3\frac{1}{4}$ per cent, but 3 per cent of this $3\frac{1}{4}$ per cent was *available* by the methods of analysis.

A cotton-seed meal fertilizer may easily contain one-third cotton-seed meal, and, if the meal had the composition of that examined above, would owe 1 per cent of its *available* phosphoric acid to the meal. If, therefore, such a fertilizer were to be analyzed by the nitric acid method, it would theoretically show a shortage of nearly 1 per cent of *available* phosphoric acid (0.90 exactly). While none of the experiments herein given exhibit as great a disparity as this, some approximate it, and it is believed that a disparity fully equal to this is quite possible. Whether the entire disparity is always due to the retention of the phosphoric acid of the meal alone, or whether in some cases the meal, while holding some of the phosphoric acid of the phosphate in check gives up more of its own, or whether, in other cases, the phosphoric acid of the phosphate in precipitating carries more of the meal's phosphoric

acid down with it, than would otherwise go, and thus lessens the disparity, is not clear. I am inclined to think that new and fresh meal will exhibit this peculiarity in a greater degree than old meal, though of that I can not speak definitely. However that may be, there seems to be not much doubt that the disparity will be greater or less according to various conditions not well understood, and may vary from a third or a half of a per cent to even as much as 1 per cent.

Six fertilizers containing cotton-seed meal were chosen. They were not laboratory mixtures, but bona fide commercial fertilizers on sale in North Carolina. They will be distinguished as 56, 76, 77, 78, 110, and 57. In each the phosphoric acid was determined by dissolving 2 grams in nitric acid plus a little hydrochloric acid with protracted heating. This is designated in the table below as "acid solution." Then in each the phosphoric acid was determined by incinerating 2 grams and dissolving the ash in nitric acid. This is designated in the table as "incineration." Following are the results:

	Total phosphoric acid.					
	56.	76.	77.	78.	110.	57.
Incineration.....	10.04	9.77	9.16	9.93	10.07	9.97
Acid solution.....	9.49	9.13	8.66	9.25	9.56	9.95
Difference.....	.55	.64	.50	.68	.51	.02

No. 57 was an old cotton-seed meal fertilizer that had been carried over from last season. The meal had completely changed color to a dark brown, so that to the eye the fertilizer would never have been judged to be a cotton-seed fertilizer. In this one alone was there no difference in the results of the two methods.

It is believed that the disparity in all these cases is probably not so great as it should be; that is to say, that the incineration method as here used probably does not give the full content of phosphoric acid for this reason. The inferiority of the solvent power of nitric acid for phosphates to that of hydrochloric acid is well recognized. I believe that this inferiority is greater when the phosphate has been ignited. To test this an acid phosphate was chosen, of which 2 grams were dissolved in nitric acid and hydrochloric acid, and the total phosphoric acid found to be 14.56 per cent. Another 2 grams were then ignited for about the same length of time that it requires to incinerate 2 grams of a cotton-seed meal fertilizer to complete ash and then dissolved in nitric acid. The determinations were parallel, so that each received the same amount of heating with acid, which was protracted. In the case of the ignited phosphate undissolved portions were plainly manifest to the eye, and the percentage found was only 13.62. The undissolved portions were filtered out and readily yielded to hydrochloric acid, giving fulsome precipitate of phosphoric acid. Next, another 2 grams were ignited and dissolved in hydrochloric acid, when the full content of phosphoric acid was readily yielded. Hence, it is concluded that had hydrochloric acid been used to dissolve the six incinerated fertilizers employed in the above experiments higher percentages would in all probability have been found. Fusion would have furnished an absolutely certain means of arriving at the undoubted maximum content of phosphoric acid, but time was limited, and simple incineration was resorted to on account of expedition; and solution in nitric acid instead of hydrochloric acid was employed after incineration, because, as the results were to be compared, it was advisable to employ the same solvent power in each case.

In addition to the six experiments described above, attention is called to the following: Two samples of cotton-seed fertilizers were procured in which another chemist had made determinations of total phosphoric by the nitric acid method. His totals were 9.13 and 9.33. I found by incineration and solution in hydrochloric acid 9.85

and 10.13, a difference of 0.72 per cent and 0.80 per cent respectively. Taking his own determinations of *insoluble*, the *available* by his analysis was 0.72 per cent short in the first instance (7.40 per cent when it should have been 8.12 per cent), and 0.80 per cent short in the second instance (7.50 when it should have been 8.30 per cent). The disparity here is excessive, but the fault is not due to the chemist, but to the method. Being one of the alternate methods of the Association of Official Agricultural Chemists, he had no reason to doubt its adequacy.

Having looked at one side of the determination of *available* phosphoric acid in fertilizers containing cotton-seed meal, let us turn to the other, namely, the determination of *insoluble*. As almost the entire content of phosphoric acid in the meal has been shown to be available, it might be anticipated that there would not be likely to be much difference in the determination of *insoluble* whether the citrate-extracted residue is first incinerated or dissolved directly in acid. Such was found by experimentation to be the fact. In fact, in every case but one (and this was the same fertilizer that was the exception to the *total* rule, namely, the old one brought from the previous season) a slightly higher *insoluble* was found by dissolving in acid directly than after incineration.

The details of the two methods of determining the *insoluble* were these: After filtering from the citrate and thoroughly washing, the filter and contents were in the first instance incinerated and the ash dissolved in nitric acid (designated in the table below as "incineration"), and in the second instance the filter and contents were introduced directly into flasks and completely dissolved with nitric acid and a little hydrochloric acid (the "acid solution" of the table below). The samples used were the same as those used in the total experiments, with the exception of 110, which was not used.

	Insoluble phosphoric acid.				
	56.	76.	77.	78.	57.
Incineration	0.84	1.80	0.86	0.87	1.59
Acid solution	1.00	1.91	1.28	1.05	1.42
Difference	.16	.11	.42	.18	.....

Whether the excess of *insoluble* by direct acid solution was due to mechanical loss in the incineration by the other method (which in these instances is not at all apprehended, though it is believed that care is necessary to with certainty guard against such loss) or whether, as is much more likely, it was due to imperfect solution of the ignited phosphate by nitric acid (a danger already pointed out), is not positively shown. But it should be remarked that in the case of 77, which is the case of greatest disparity, the undissolved portions were manifest to the eye, and it is the writer's conviction that had hydrochloric acid been used instead of nitric there would have been no material difference in the results of the two methods, either in these particular determinations, or in any other determinations. It is regarded as certain, therefore, that there will be found no material difference in the *insoluble* by whichever way determined.* This being true, the *available* will vary directly and exactly as the *total*; and, therefore, by just so much as a *total* is short on account of the inadequacy of the nitric acid method when used on cotton-seed meal fertilizers, by just so much will the *available* be short.

*Corroborated by determinations on phosphoric acid, reporter's sample No. 3, which showed:

	Per cent.
Per cent insoluble P_2O_5 by ignition and solution in HCl	2.67
Per cent insoluble P_2O_5 by dissolving filter and all in HCl_3 and a little HCl (without igniting)	2.64

Now a few words as to what method is adequate, and a very few experimental determinations on this point, and the subject will for the present be laid aside. It is a matter of regret to the writer that the time was not at his disposal for more extended experimentation on the subject. Nevertheless he is none the less convinced, on account of the limited number of experiments here presented, of the truth of the point urged.

In order to compare the *total* as made by several different methods sample 110 was chosen. This sample was sent by a fertilizer company who took a fair sample of a large lot of goods at their factory, thoroughly mixed the sample and sent one-half to the writer and one-half to a chemist in another State. The *total* was determined first by fusing 2 grams of the fertilizer with a mixture of equal parts of carbonate of soda and nitrate of potash, as giving with certainty the maximum content, and furnishing a standard for comparison. It was then determined by incineration and solution in hydrochloric acid, by incineration and solution in nitric acid, by solution direct in hydrochloric acid with chlorate of potash, and lastly by solution direct in nitric acid and a little hydrochloric acid. Following are the results:

	Per cent.
Fusion.....	10.14
Incineration and solution in HCl	10.09
Incineration and solution in HNO ₃	10.07
Solution direct in HCl + KClO ₃	10.11
Solution direct in HNO ₃ + little HCl	9.56

From the above it seems that in this case all the methods save the nitric acid methods were adequate, but it is not apprehended that this will hold good in all cases. For, while here incineration and solution in nitric acid sufficed, there is certainly the danger of imperfect solution already referred to; and while here also solution in hydrochloric acid with potassium chlorate sufficed, it has already been shown that this method failed to extract, from the meal alone, more than half its content of phosphoric acid.* Fusion is, of course, always adequate, but too time-consuming, if any other adequate method less so is at hand. It seems probable that incineration and solution in hydrochloric acid furnishes all that could be desired.†

It is in point to add that in this case the writer reported to the manufacturers a *total* of 10.11 per cent, this being an average of the first four determinations. The *insoluble* found by incineration and solution in hydrochloric acid was 1.47, making an *available* of 8.64. It is not known what method the chemist used to whom the other half of this sample was sent, but his *total* was 9.72, his *insoluble*, 1.50 and his *available*, therefore, 8.22. Note that the two *insolubles* are practically the same, and that, therefore, his *available* is less than the writer's by practically the same amount that the writer's *total* is greater than his.

The following results, obtained on sample No. 3 (containing cotton-seed meal) of the samples sent out by Dr. Burney, the reporter on phosphoric acid, for 1890, were submitted to that reporter, and are here appended as corroborative of the conclusions reached in the foregoing paper:

	Per cent.
I. Total P ₂ O ₅ , by evaporation with Mg (NO ₃) ₂ , ignition and solution in HNO ₃	12.10
II. Total P ₂ O ₅ , by simple incineration and solution in HCl	12.08
III. Total P ₂ O ₅ , by solution in HCl + KClO ₃ , two determinations { 11.78 } aver-	
aged.....	11.76

* It did not suffice in sample No. 3 sent out by the reporter on phosphoric acid.

† Corroborated by determinations in sample No. 3 sent out by the reporter on phosphoric acid, which showed:

	Per cent.
Total P ₂ O ₅ by ignition with Mg (NO ₃) ₂ and solution in HNO ₃	12.10
Total P ₂ O ₅ by simple ignition and solution in HCl.....	12.08

IV. Total P_2O_5 , by solution in HNO_3 + little HCl , two determinations	$\left\{ \begin{array}{l} 11.49 \\ 11.56 \end{array} \right\}$
averaged	11.53
I. Insoluble P_2O_5 . After filtering from citrate solution and thoroughly washing, the filter and contents were ignited and dissolved in HCl .	2.67
II. Insoluble P_2O_5 . After filtering from citrate solution and thoroughly washing, the filter and contents were put direct into a flask and dissolved in HNO_3 + little HCl	2.64

Mr. Gibson presented the following paper:

DIFFERENCES IN THE DETERMINATION OF REVERTED PHOSPHORIC ACID BY THE OFFICIAL METHOD OF ANALYSIS.

By CHARLES GIBSON.

Having found it utterly impossible to make my analyses for the amounts of reverted phosphoric acid in several consignments of high-grade aluminic phosphate agree within several per cent with those of Messrs. Stillwell & Gladding, of New York, both of us using the official method, I proceeded to investigate by numerous experiments. The conclusions I have arrived at, and the reasons therefor, together with a few of the results I and others have obtained, I now propose to lay before this association.

When this material was first placed on the market my company, thinking perhaps we could use it profitably and advantageously in other respects in our factory, purchased a few consignments; and at the suggestion of the vendors we readily agreed to settle on the analyses of Messrs. Stillwell & Gladding, who were chemists of great eminence; and the fact of their using the official method of analysis contributed in no small degree to our ready assent. Their analyses of the different consignments, which they have since informed me were by the official method strictly as to time, temperature, etc., were checked by me, not using the official method however, but using the method which I use in controlling the work in the factory—the alkaline citrate method of Joulie—our results invariably agreeing to within one-tenth of 1 per cent. Goods were in due time made up with this material as one of the ingredients, and samples drawn and submitted to the chemists of the various States where they were likely to be sold. On the reports from the State chemists coming to hand we were surprised to find that they all, without a single exception, gave a very much lower percentage of available P_2O_5 than we had a right to expect, amounting to about 15 per cent on the ton of aluminic phosphate used.

Investigation proved that there had been no mistake in the weighing out of the materials. The proportions were found to be correct, and nothing of a retrograde nature could be discovered, at least with the Joulie method of analysis. But, in using the official method on the prepared goods, I obtained results which agreed completely with those of the State chemists. Evidently there was something wrong somewhere, and an analysis of a sample drawn from one of the consignments of aluminic phosphate (using the official method, instead of the alkaline method) indicated in which direction the trouble lay. This analysis gave results of about 15 per cent available P_2O_5 less than had been found by Messrs. Stillwell & Gladding. Repeated analyses with the same and other solutions failed to change this, and an examination by the official method showed the same state of things with regard to every consignment we had received. Through the kindness of two of the State chemists, the Hon. M. A. Scovell, of Kentucky, president of this association, and Prof. H. A. Huston, of Indiana, I have been able to verify the correctness of my results, at least as far as one consignment is concerned, as the following will show:

Stillwell & Gladding found 34.73 per cent available P_2O_5 ; total P_2O_5 , 47.04 per cent.

Mr. Scovell, 20.31 per cent available P_2O_5 ; total P_2O_5 , 44.25 per cent.

Professor Huston, 19.40 per cent available P_2O_5 ; total P_2O_5 , 45.46 per cent.

My own, by official method, 19.70 per cent available P_2O_5 ; total P_2O_5 , 46.7 per cent.

My own, by alkaline method, 34.74 per cent available P_2O_5 ; total P_2O_5 , 47.0 per cent.

This matter thus assumed for us a serious aspect, for here we were both buying and selling on analytical results obtained by the official method, and yet, from a cause over which we had not the slightest control, we were subjected to a financial loss of very serious proportions, amounting to between \$10 and \$12 per ton of aluminic phosphate used.

Continuing the investigation with a view of finding whether or not this serious evil could be avoided, I found that infinitesimal variations in the preparation of the ammonia citrate solution of the official method very materially changed the results in the determinations of reverted P_2O_5 in this material. Although in the preparation and use of the ammonia citrate solution the directions as laid down in Bulletin No. 24, page 224, were followed with the utmost care, I was totally unable to prepare two solutions that would give anything like concordant results; and even with the same solution they were anything but uniform. The cause of this I found to be owing to very slight unavoidable variations in the composition of the ammonia citrate solution. I also found that the slightest inclination to acidity very largely affected the insolubility of this material. Now, from the mode of its preparation, it is evident that a perfectly neutral solution of citrate ammonia is practically unattainable, although the variations from neutrality must of necessity be of the minutest kind if proper care is used. These variations must either incline to alkalinity or acidity; but a little consideration would lead to the belief that, in almost every case (except where precautions are taken to insure the reverse), the inclination is to acidity.

I therefore prepared a solution of citrate of ammonia in the same manner as I conceived the majority of analysts, who did not know of the effect of this acidity, might prepare it. The directions in Bulletin No. 24, page 224, were followed with great care, and neutrality made by the addition of ammonia hydrate until the solution ceased to show acidity with blue litmus paper of great delicacy. Red litmus paper of great delicacy was also unaffected. I tried rosolic acid, but could do no better. We will call the solution A. Another solution, B, was made by adding ammonia hydrate to a portion of A until it showed a very faint alkalinity with delicate red litmus paper. The quantity of ammonia hydrate necessary to do this was about 1 cubic centimeter of a solution of the strength of 22° Baumé, to 1 liter of the A solution. I also prepared, with a view of obtaining a comparison of the two methods, a solution, C, according to the directions of M. H. Joulie, making it, as directed, strongly alkaline.

Before trying these solutions on the aluminic phosphate, I was curious to see what differences in effect, if any, they would produce on calcium phosphate. One gram of ground South Carolina rock containing 27 per cent P_2O_5 was taken in each experiment and digested without attempting to remove the small quantity of water-soluble (if indeed any were present). The official method was carried out strictly as to time, temperature, etc., with regard to A and B; and Joulie's directions in everything except time, which was only one-half hour instead of one hour with regard to C, no heat being applied in this case, it being digested at the temperature of the laboratory. The following results were obtained, in per cent of reverted P_2O_5 :

A.	B.	C.
1.01	0.75	0.73
0.90	0.73	0.74
0.83	0.76	0.77
Mean, 0.913	0.746	0.746

Three experiments were now made in every respect the same as above, except that all were digested one hour, the time specified in Joulie's method, and the following results, in per cent of reverted P_2O_5 were obtained :

A.	B.	C.
1.85	0.787	0.73
1.83	0.74	0.78
1.86	0.76	0.77
Mean, 1.846	0.761	0.76

Five different portions of 1 gram each were now digested in C for four hours, and I obtained the following percentages of reverted P_2O_5 : 0.71, 0.78, 0.79, 0.70, 0.75. Mean of the five: 0.746, or the same as B and C gave when the substance was digested only one-half hour.

There is great significance in the results thus obtained. The continuous dissolving action of the solution A is apparent; while both the B and C solutions cease to act as soon, apparently, as all the available P_2O_5 has been dissolved, which is within the first half hour; and an indefinite extension of the time of digesting, especially in the case of the C solution, seems to produce no further effect. Thus solutions B and C have been prepared, which, contrary to the generally accepted belief, will not go on continuously dissolving out P_2O_5 from calcium phosphate as long as any remains undissolved, provided enough time is allowed; and we have here (if, by further experiment, this is found by others to be true) a true measure of the availability of a phosphate, or at least a means of separating more sharply than we have hitherto been able to do soluble calcium phosphates from insoluble; and, with such a solution, which can be made by a very slight modification of the present official solution, the time element in the official method would cease to be an essential, as it is now, and would, in all probability, give much more accurate results, as well as conduce, more than anything else, to constancy and uniformity of results. From these experiments we perceive that a solution inclined to acidity, like solution A, tends, on calcium phosphate, to err on the side of too high a percentage of reverted phosphoric acid. The error is probably very small, but still that is the tendency. When, however, such a solution is used on aluminic phosphate, the reverse is the case to such an extent as to make the official method utterly worthless for the analysis of this material.

One gram of the aluminic phosphate containing 47 per cent P_2O_5 , with 34.74 per cent available P_2O_5 , according to Stillwell & Gladding, was digested in each of the solutions A, B, and C, strictly following as to time, temperature, etc., the official method with A and B; and Joulie's method, except as to time, which was one-half hour, instead of one hour, with C. The water-soluble, being insignificant in amount, was not removed before digesting. The following are the results obtained :

A.	B.	C.
19.80	31.24	26.18
19.90	33.44	27.63
19.63	30.31	26.92
Mean, 19.77	31.66	26.91

One gram of the material was now treated in every respect the same as in the last experiments, except that the digestion was one hour instead of one-half hour in all cases; and gave the following results, in per cent available P_2O_5 :

A.	B.	C.
31.48	34.68	34.74
32.11	34.79	34.72
30.59	34.73	34.74
Mean, 31.39	34.73	34.73

It seems incredible that two solutions differing so very slightly in composition as do the solutions A and B should give such widely divergent results, the difference between the mean of the three results obtained by solution A and the mean of the three obtained by solution B, by digesting one-half hour, being no less than 11.89 per cent available P_2O_5 . The lack of concord in the results obtained by each solution separately, together with the wide differences in the means of the results obtained from the three solutions, suggest the conclusion, however, that, in the case of each solution, the official time (one-half hour) was insufficient to dissolve the material.

By digesting one hour, concordant and uniform results are obtained by solutions B, and C. The results from A are still very much lower than B, although the difference is not so great as it was in the previous experiments. I found that the material was capable of being almost completely dissolved in all three solutions, if sufficient time was given.

Now, I am of the opinion that a critical examination of the ammonia citrate solutions of the majority of State and analytical chemists would reveal the fact that they are very close in composition to my solution A, in fact slightly inclined to acidity the fact of slight acidity in the solution affecting the insolubility of the aluminic phosphate not being generally known; while the chemists of the manufacturers, and perhaps a few others, being cognizant of this fact, have taken precautions to have their solutions incline to alkalinity rather than acidity. In some such way as this may we account for a considerable portion at least of the large difference in the amounts of available P_2O_5 found by Messrs. Stillwell and Gladding on the one hand, and the State chemists and myself on the other. The results obtained in these experiments, which are only a few out of many that I have made, warrant, I think, the following conclusions:

(1) That the official method, as it stands at present, is incapable of giving results on which an equitable adjustment of values—especially of aluminic phosphates—can be made, and it is urgently and imperatively necessary that either such modifications be made in it as will assure accuracy in all instances and under all circumstances, or that it be abandoned in favor of some other that may be depended upon.

(2) That it is possible to make such modifications in it as will enable analysts to obtain uniform and concordant results.

(3) That these modifications, if made in the direction which I will suggest, would conduce to greater accuracy and uniformity of results in the analysis of calcium phosphates.

With the view of making the comparison with the alkaline citrate method as accurate as possible, the amounts of available P_2O_5 obtained by it in these experiments and here given were determined as pyro-magnesium phosphate, checks being made by duplicates determined volumetrically. The agreement between the pyro-magnesium and volumetric determinations was very close, never varying more than 0.07 per cent. I have largely used this method during the last seven or eight years, and I have found it much more satisfactory than any other. The results obtained by it are reliable and uniform. It does not require that nicety and delicacy of manipulation and adjustment of solution that the official and other methods require, and there is therefore

less liability to error. It is more expeditious, the available being determined in one operation. The presence of organic matter does not impair the accuracy of the results either for total or available P_2O_5 , and it is therefore unnecessary to destroy it. The results can be obtained either gravimetrically or volumetrically. The only drawback I find in the use of the method is that, in order to make sure of a complete precipitation of the ammonia magnesia phosphate, after adding magnesium mixture and vigorously agitating it, I find it necessary to let it stand over night. As a substitute for the present official method, if the association decides to abandon it, I think it might go farther and fare worse; and in any case it ought to be made an alternate method.

The present official method has been clearly demonstrated to be defective, erroneous, deceiving, and the cause of great financial loss, in one case at least; and this association, with whom alone rests the responsibility and to whom alone we must look for a remedy, will, I am sure, recognize the necessity, and make some immediate change that will not only restore confidence, but will conduce to uniformity and constancy of results, and insure accuracy and justice.

I am aware that capricious changes in official methods of analysis are to be deprecated, but in view of the facts here presented, I realize that this association must perforce take action in the premises. Therefore, with a full consideration of all the facts, and the conclusions fairly deducible from these experiments, and with a desire to aid the association in solving the problem with which it is now brought face to face, firmly believing that the changes here advocated will be a full and complete remedy for the defects in the official method which have been brought to light, I most respectfully submit the following suggestions:

- (1) That instructions be given to add ammonia hydrate to the ammonia citrate solution, until a faint alkalinity is perceptible with red litmus paper.
- (2) That the time of digesting be made one hour at $65^{\circ} C$.
- (3) That Joulie's alkaline citrate method, with or without the modification of weighing as pyro-magnesium phosphate, be made an alternate method.

Mr. Huston said that he had done some further work in regard to the solubility of the so-called reverted phosphoric acid in citrate of ammonia solution, an abstract of which here follows.

ACTION OF AMMONIC CITRATE ON HIGH-GRADE ALUMINIC PHOSPHATE.

By H. A. HUSTON.

In the latter part of July a sample of high-grade aluminic phosphate was submitted to me for analysis. The results desired were the amounts of total and of "available" phosphoric acid present. As the material was quite different from the ordinary fertilizer stock a series of experiments were made to determine the effects of varying the conditions used in the official method for available. Three methods for determining total phosphoric acid were used and gave closely agreeing results.

The material was stated to be anhydrous phosphate of aluminum, which had been calcined. It was found to contain 45.46 per cent of phosphoric acid and 7.25 per cent of silica. There was no soluble phosphoric acid present in the sample. The work on available phosphoric acid was made by using in all cases 100 cubic centimeters of the official citrate solution. In the fourth series solid citric acid and ammonic hydrate were added. The results appear in the following tables:

SERIES 1.—Effect of increasing the time of digestion.

[Amount taken, 2 grams. Temperature, 65° C.; 100 cubic centimeters citrate solution.]

Time of digestion.	Per cent dissolved.	Fraction of total phosphoric acid dissolved.
One-half hour	21.24	46.75
One hour	31.70	67.53
Two hours	36.92	81.10
Four hours	40.80	89.67
Six hours	41.00	90.11
Ten hours	42.70	93.85

SERIES 2.—Effect of changing the temperature at which the digestion was conducted.

[Amount taken, 2 grams; time, thirty minutes; 100 cubic centimeters citrate solution.]

Temperature.	Per cent dissolved.	Fraction of total phosphoric acid dissolved.
40° C.	2.18	4.79
50° C.	5.52	12.10
65° C.	21.24	46.75
75° C.	32.90	72.30
85° C.	39.52	87.90

SERIES 3.—Effect of changing the amount of phosphate taken.

[Temperature, 65° C.; time, thirty minutes; 100 cubic centimeters citrate solution.]

Amount of phosphate taken.	Per cent dissolved.	Fraction of total phosphoric acid dissolved.
$\frac{1}{2}$ gram	16.80	36.9
1 gram	18.26	40.1
2 grams	21.24	46.7
3 grams	23.22	51.0
5 grams	24.66	54.2
10 grams	28.64	62.9

SERIES 4.—Effect of making the citrate solution acid or alkaline.

[Amount taken, 2 grams; time, thirty minutes; 100 cubic centimeters citrate solution.]

Amount of acid or alkali added to the solution.	Per cent dissolved.	Fraction of total phosphoric acid dissolved.
2 grams citric acid	17.21	37.21
1 gram citric acid	18.26	39.49
0.75 gram citric acid	17.84	38.58
0.50 gram citric acid	19.98	43.20
0.10 gram citric acid	21.08	45.60
0.05 gram citric acid	21.14	45.70
Neutral solution	21.32	46.10
Ammonia enough to neutralize 0.05 gram citric acid	23.44	50.70
Ammonia enough to neutralize 0.10 gram citric acid	24.38	52.70
Ammonia enough to neutralize 0.50 gram citric acid	26.02	56.30
Ammonia enough to neutralize 1.00 gram citric acid	30.78	66.60

The only set of the above results that seems to require any special comment is series 3, where the results are rather unexpected. The work in this direction will be continued in order to find out whether the peculiar effect is due to the fact that the digestion is stopped before the solution is complete, or whether a solution of aluminic phosphate in ammoniac citrate really has a greater solvent power than the original solution of ammoniac citrate.

The commercial importance of this matter will appear from the following: Suppose the high-grade phosphate is used in making up goods to the extent of one-fourth their weight. Then there should be 5.31 per cent of available derived from the aluminic phosphate. But if the results in series are correct there would appear on analysis only 4.20 per cent of available from this source.

The matter is also of considerable interest from a purely scientific standpoint.

The president said that in order to facilitate the disposition of the subject it would be well to take up first the recommendations of the reporter, debating such amendments and suggestions as should be offered thereon, and then consider any further amendments and other matters that might be presented in relation to the subject.

The first recommendation was again read, and it was moved that the same be adopted. Seconded.

Mr. McDonnell said that he thought the proposed change would make but a very slight difference in the amount dissolved. He had made a number of experiments on ordinary fertilizers, and had found that by washing up to 250 cubic centimeters and then 250 cubic centimeters more would only increase the soluble on the average probably 0.1 of 1 per cent, and 50 cubic centimeters would make a difference of only a few hundredths of a per cent.

Mr. Huston said that his experience was similar to that of Mr. McDonnell. He had never been able to detect any difference after the first 200 cubic centimeters, but perhaps he had washed with a smaller quantity of water than others used; he made as many washings as possible with as little water as possible; he thought that he did not use more than 2 or 3 cubic centimeters of water, and he got 30 washings without any trouble. The association was raising the solution at the rate of about 50 cubic centimeters a year, and that had better be stopped.

Mr. Burney said that he was strongly opposed to making unnecessary changes in methods. He would call attention to the fact that the official method now was not 250 cubic centimeters; the directions were "not less than 250 cubic centimeters." He had made it 300 cubic centimeters, but was perfectly willing to adopt 250 cubic centimeters as a fixed quantity; he thought that some fixed quantity should be adopted, and had supposed that 300 cubic centimeters would probably meet with the approval of most of the members of the association.

Mr. Gaines said that after washing with 200 cubic centimeters very little more was obtainable, scarcely 0.1 of 1 per cent. He moved that 250 cubic centimeters be adopted.

Mr. Voorhees said that a point which he wished to make was that on some high-grade superphosphates the washing made a considerable dif-

ference, and 200 and 300 cubic centimeters were not the same thing. He washed to 300 cubic centimeters, but there was no fixed limit prescribed.

Mr. Frear said that the unnecessary purchase of new apparatus was a matter that deserved consideration. He had a full stock of 250 cubic centimeter flasks and did not care to throw them away. In his laboratory the tests had been very carefully made under his own supervision, and with exact reference to the particular point now in question, and he had been unable to see any practical difference on quite a high grade of fertilizers. There seemed to be no necessity for adding labor without compensatory benefit, and he therefore preferred that the amount should be fixed at 250 cubic centimeters. He agreed with the reporter that it would be better to have a uniform amount, although he thought that in most cases the difference would not be large.

Mr. Kedzie said that it would only be necessary to strike out the words "not less than." The direction would then read (page 224): "wash with water until the filtrate measures 250 cubic centimeters."

The amendment was agreed to, and the recommendation as amended was adopted.

The second recommendation was again read and it was moved that the same be adopted. Seconded.

Mr. Voorhees asked what was the object of washing with citrate solution.

Mr. Burney said that he had, of course, expected serious opposition to the motion; for that he was fully prepared. On the other hand, he fully realized that no two filter pumps worked alike, and that to recommend one in the official method was to necessitate varying lengths of time for which the substance should be exposed to the action of the solvent; in other words, the method was one which caused the chemists to work under differing conditions, and that ought to be obviated if possible. So long as filter pumps were used the chemists could not hope to work alike. He had recommended the fluted filter because, so far as he could learn, it worked as rapidly as a filter pump. In the State laboratory where he worked the filter pumps were of very little use. The association could adopt a folded filter of such a kind that the filtration would take place at Washington in practically the same time as in South Carolina, and if the method recommended was equally convenient with that of the filter pump he saw no reason why the association should not adopt it, but every reason why it should.

Mr. Myers asked whether the filter pump used by Mr. Burney produced exhaustion.

Mr. Burney said that it did so but very slightly. For two years he had used with most satisfactory results a fluted filter which he exhibited. Several members of the association had used the proposed method on the samples, and spoke of it in the highest terms; he hoped that they would speak in regard to it now, as he felt that some change was very much needed.

A question had been asked concerning the washing with citrate solution. Every one knew that the suggestion came from Fresenius; it appeared in the original and in the translation. Fresenius recommended washing two or three times with half-strength ammonium citrate, and the object was to prevent the choking of the filter paper, a precautionary measure which was frequently necessary; the paper sometimes choked when water was added after draining off the citrate solution. Some determinations on the samples, using both methods, were as follows: The insoluble in No. 1, using the ammonium citrate half-strength, gave 4.21; without, it gave 4.23. No. 2, with ammonium citrate half-strength, 1.16; without, 1.24. No. 3, with ammonium citrate half-strength, 2.71; without, 2.85. In the last case the filter paper choked on the addition of water. Only one determination was made in each case.

Mr. Voorhees said that the determinations stated were within the limit of error in each case. He asked whether on the same sample, washing with citrate and with water, results within the limit of error could always be obtained.

Mr. Burney said that they could not. He saw no good reason for believing that the evils hinted at would arise. He thought that so careful a workman as Fresenius must have carefully settled the point before assuming the responsibility of recommending it in such a standard work as his unquestionably was, and as for himself, the figures just cited settled it to his entire satisfaction. It was undoubtedly true that the clogging of the filter paper would cause more trouble than could arise from the use of the half-strength citrate solution. The solution ran through with great rapidity, and acted but for a moment upon the residue remaining on the filter paper.

Mr. Voorhees said that filtering through folded paper was recommended last year, when he had suggested to the association that it be adopted, he having tried it for a whole year in the determination of phosphoric acid with very-good results; the work had been continued in the same manner during the past year, and was found eminently satisfactory. For washing he had used the citrate solution, half-strength, for some time, and after a considerable number of determinations had concluded that the addition of citrate was not advantageous, the results without it being quite as good, and the filtration more rapid except on materials containing considerable oily matter, bones, for instance. On the whole he had concluded that it was better to use the water rather than the ammonium citrate solution.

Mr. Burney asked whether Mr. Voorhees meant to say that the filtration went on more rapidly without the use of half-strength ammonium citrate than with it.

Mr. Voorhees said that such had been his experience except on unusual samples of raw bone and others of similar character.

The president said that there were two important points in the recommendation, and suggested that a vote be first taken upon the question whether the fluted filter should or should not be used.

Mr. Gaines said that if Mr. Burney would use a Bunsen filter pump he could secure rapid filtrations and uniform results.

Mr. Burney said that a Bunsen pump required a well 40 feet deep or its equivalent. That could not easily be had.

Mr. Gaseoyne said that a Richard pump would give much better results than a Bunsen pump. He should be sorry to have the association do away with the pump. His trouble occurred when he commenced to wash with cold water, particularly on fertilizers containing fish and cotton-seed meal. He thought that filtration was much more rapid when warm water was used for the washing; that gave him no trouble by clogging the filter, but passed right through.

Mr. Battle said that he was utterly opposed to the adoption of the fluted filter; he thought that ordinarily the pumps were strong enough, and that the washing of the fertilizer in the fluted paper would be very troublesome indeed; he had not tried it. In any event he thought that the change should not be made at this time; the association should at least postpone it for a year, and a trial could be had in the mean time.

Mr. Frear said that in his laboratory from ten to twelve determinations of the insoluble were made at one time; there were six filter pumps in the laboratory, and he had found it almost impossible to do the work so as to have the exposure the same on all the samples without great difficulty and danger of inequality by the use of the filter pump. He used the folded paper altogether, and generally two men had all they could do to keep the washing going on with twenty samples at one time without the use of the filter pump.

Mr. Huston said that he kept from ten to fifteen filter pumps running all the time, and did not believe that he could do without them. He made citrate-soluble in everything, and to him the pump was a necessity. He had never seen a filter which would let the first 100 cubic centimeters through inside of two or three hours in a citrate solution. His way was to decant and wash; he did not undertake to make a filtration on any single filter. His assistant said that he could do nothing without a pump; the washing would never be finished without it. He would suggest that the funnel of the filter pump be surrounded with hot water for the first 100 cubic centimeters.

The president said that in his laboratory, with the goods he had to deal with, it would be a very serious disadvantage to dispense with the filter pump.

The motion to adopt the second recommendation was lost.

The third recommendation was again read, and it was moved that the same be adopted. Seconded.

Mr. Huston moved that the recommendation be amended so as to apply to bone and bone meal as well as to cotton-seed meal.

Mr. Burney accepted the amendment.

Mr. Battle said that the recommendation seemed to him a very wise one. In his State the magnesium nitrate had worked well in almost all

fertilizers containing organic matter. He thought it might be advisable to extend the recommendation so as to cover all fertilizers containing organic matter.

Mr. McDonnell said that he did not think the change at all necessary. He would admit that he had but little experience in the use of the method, but he had tried it with the No. 3 sample and had difficulty in getting concordant results on the total acid; he got no higher result than with the ordinary method. He thought that to adopt the recommendation would be to return to the method of several years ago. The matter had been discussed in previous meetings.

Mr. Frear said that he saw no need of adopting the method, which presented some inconveniences, until it should be proven that the other methods were unsatisfactory. In the case of cotton-seed meal it did seem to be advantageous, but he was unwilling to see it extended to all fertilizers containing any kind of organic matter, and he should much prefer the adoption of the recommendation as originally submitted by the reporter, with the idea that the method be further and more carefully tested with reference to bone goods and goods containing other forms of organic matter during the coming year.

Mr. Gascoyne said that it was almost impossible to get the entire amount of phosphoric acid from cotton-seed meal with any of the wet processes; the only method by which that could be done was the magnesium nitrate method; but he saw no reason for extending that method to any other substance.

Mr. Dancy asked in what way it was objectionable to simply ignite the fertilizers and burn the organic matter to ash without the magnesium nitrate.

Mr. Gascoyne said that if insoluble phosphoric acid was present there would be danger of pyro-phosphate forming.

Mr. Dancy said that he had made tests in that regard; he had ignited acid phosphates for a long time and always found that the full content yielded to hydrochloric acid; he had never found that after ignition it could not be dissolved in concentrated hydrochloric acid.

Mr. Kedzie asked that the question be divided, the adoption of the method recommended for bone and for cotton-seed meal to be voted upon separately.

Mr. Burney said that lest the recommendation should not be adopted he wished to direct the attention of the association to the third table, an inspection of which would show but one or two cases where the phosphoric acid when determined by the nitro-hydrochloric method even reached the average, and he believed that the average was too low.

The motion to adopt the method recommended for fertilizers containing bone and bone meal was lost.

The motion to adopt the method recommended for fertilizers containing cotton-seed meal was carried.

The fourth recommendation was again read.

Mr. Burney said that the fourth recommendation was made as a mere matter of advice, and was not intended to be obligatory at all; it was hardly a recommendation, and no vote upon it was necessary; it would appear in the report as a suggestion.

The president said that in order to facilitate action the adoption of the method for the ensuing year would be considered section by section, reference being made to the report of the last meeting, pages 224, 225.

By several motions, which were carried, the methods prescribed in 1889 (page 224) for preparation of sample, determination of moisture, and water-soluble phosphoric acid were readopted without change.

It was moved that the method for citrate-insoluble phosphoric acid remain as it was last year (pages 224, 225). Seconded.

Mr. Williams, referring to the paper read by Mr. Gibson, said that at first sight it might appear that the high result of 34 per cent available phosphoric acid in the case stated was obtained only by himself (Mr. Williams) and Messrs. Stillwell & Gladding. On the contrary, a great number of official chemists, working strictly by the official method, got precisely the same result, which showed that there was something wrong in the method itself, and he thought he knew what that was. In December, 1886, and January, 1887, his firm sent samples to chemists in all parts of the country, and the following table would serve to show their agreements on available phosphoric acid:

	Per cent.
H. C. White	40.10
Charles W. Dabney	39.48
N. W. Lord	37.37
Stillwell & Gladding	40.16
F. A. Genth, Pennsylvania State Board of Agriculture ...	40.05

In February, 1889, the question again arose; certain parties who had bought his firm's goods had failed to get correct results, and samples were again sent to several chemists with the view of ascertaining whether the Keystone Chemical Company or the method was in error. On this particular sample his own analysis gave 33.52 per cent available phosphoric acid, and the following returns were received from other chemists:

	Per cent.
W. J. Gascoyne	32.88
Mr. Simon	31.03
Shepard Laboratory	26.36

A little later, in July, 1889, the question again coming up, he desired to make sure that he and Stillwell & Gladding, who usually acted as the company's arbitrators, so to speak, employed the official method, and a third sample was sent out, on which his own test gave 30.37 per

cent available phosphoric acid. On this sample the following returns were received :

	Per cent.
Stillwell & Gladding.....	30.60
Mr. Buck	30.87
W. J. Gascoyne.....	31.02
Shepard Laboratory.....	25.22
Mr. McCandless.....	32.35
Pringle Frost.....	30.25
H. C. White.....	31.27

Here were seven analyses all agreeing very closely, and only one dropping low. Hitherto the greatest discrepancies he had ever found amounted to 4 per cent, or thereabout, until Mr. Gibson's case, in which it amounted, he believed, to 15 per cent.

In studying out this question he had come to the conclusion that the slightest trace of acidity in the solution would cause the available phosphoric acid in the material to drop 3 or 4 per cent, and that the discrepancies were partially due to such slight traces of acidity in the so-called neutral citrate of ammonia solution. He had never succeeded in making such a solution, and others agreed with him in saying that to get an absolutely neutral ammonium citrate solution was impossible, and yet with the least degree of acidity in the mixture the results would go down enormously. If the question of slight acidity could be avoided fair agreements could be had.

In or before 1887 the official method for treating citrate insoluble goods was to place the flask in the bath at a temperature of 65° and digest at that temperature for thirty minutes. While that was the official method he had, comparatively speaking, no trouble with his goods, the discrepancies not exceeding from one-half to 1 per cent, and all the official chemists to whom the goods came agreeing fairly well. But in 1887 came the alteration that the flask was to be maintained simply in the bath, which was at a temperature of 65° for thirty minutes, which made fun for the official chemists, but not for the manufacturers. One trouble was that having a highly concentrated material, giving perhaps 33 or 35 per cent available phosphoric acid, but having at the same time only the same quantity of citrate of ammonia solvent as was used on other goods, the solvent had a great deal of work to do.

Again he had found that the question of time depended greatly on the quality of flask used. He had written to many chemists, inquiring how long a time it took for their citrate of ammonia in the flask to attain the temperature of 65°. Some said that they could get it up to that point in from three to four minutes; Stillwell & Gladding claimed that between four and five minutes was a long enough time; for his own part, he could not get it up to 65° in any flask he had tried under seven or eight minutes, and other chemists said that it took them nine or ten minutes. Stating it in that way it did not seem a great deal, but put in the converse form there was seen to be an enormous differ-

ence. So long as the directions read "hold it at 65° for thirty minutes" these discrepancies were of very little practical moment. On that point he had made a series of experiments, and with regard to the question of time his results differed widely from those shown by Mr. Huston. Having the bath at 65°, and reckoning the time from the moment of inserting the flask, the flask was held in the bath for thirty minutes, as directed in the official method, and the insolubles actually found were 12.26 per cent. Forty minutes (amounting in the circumstances under which he worked to about thirty-one minutes at 65°) gave 7.81 per cent insolubles; in fifty minutes they became 5.86 per cent, and in sixty minutes they only dropped to 5.31 per cent; fifty-five minutes gave 5.83 per cent, practically the same as at fifty minutes. These were not single experiments, but the mean of certainly five experiments in each case, so that to all intents and purposes the extraction seemed to stop in from fifty minutes to one hour, showing somewhat conclusively that simply being in a water bath at 65° for thirty minutes would not extract all that was soluble in the citrate of ammonia; there was not time enough, and the reaction was incomplete. If for any particular reason the citrate of ammonia could get at it easily and completely it would give a very high available phosphoric acid, but when it was given thirty minutes at 65° the discrepancies disappeared in a very marked degree.

Probably all had noticed that ammonium citrate solution made on a given day as neutral as possible would on the next day be distinctly acid—perhaps not in twenty-four hours, but certainly within a very short time; it would become acid sooner or later, and a very slight acidity was sufficient to make considerable difference on any mixture containing the goods of his company. So far as those goods were concerned he thought it would be strongly advisable, in order to get uniformity, to direct that the citrate of ammonium solution, instead of being neutral, should be faintly alkaline, and that the time of extraction should be made at least thirty minutes at 65°.*

Mr. Robinson said that his practice was to heat the ammonium citrate solution in a closed flask before using it, so that it was put in at the temperature of 65°. That was not the official method, but seemed to be really implied in it, and he had adopted it after experiencing much dif-

* In a communication received by the secretary subsequent to the meeting Mr. Williams requested that the following addition be made to his remarks:

I may add in further corroboration of my position that since making these remarks in August, 1890, another sample of our Keystone Concentrated Phosphate was analysed by several chemists, strictly by the official method, in October, 1890. The results are—

[Available phosphoric acid.]		Per cent.
Messrs. Stillwell and Gladding		35.40
W. J. Gascoyne, Baltimore		33.77
Mr. Johnson, Connecticut		35.18
Mr. White, Athens		32.93
W. J. Williams, Philadelphia		35.09

ficulty with the ammonium citrate solution. As has been said, the solution would become acid. He had therefore, after making the solution as neutral as possible, added 3 or 4 cubic centimeters of coralline solution, and this gave a constant indication of the solution's exact condition; he could tell by looking at it whether or not it had become acid, and a drop or two of ammonia would correct the acidity. He got the best results by having the solution slightly alkaline, with the slightest purplish tinge or hint of a reaction.

Mr. Huston said he did not believe that the association could work on hints and tinges of alkalinity without being worse off than before. Moreover, according to his experience, the citrate solutions became alkaline rather than acid.

Mr. Gibson said that the paper he had read showed the results obtained by Mr. Huston on aluminic phosphate to be low, with a tendency to acidity. In all probability no phosphoric acid would have been dissolved after one hour had an alkaline solution been used. He would, therefore, move that the words "thirty minutes," in the first line on page 225, be stricken out, and the words *one hour* inserted in place thereof.

The motion was seconded.

Mr. Frear said that he would object very decidedly to such a change being made until it was better known what the facts really were, there being presented two sets of results which were not at all alike. He would further object to the adoption of any change resting upon facts relative to aluminic phosphate until their bearings upon calcium goods should be known. He fully realized the necessity for promptness of action, but the way proposed did not seem to be a safe one in which to go about the matter. He would be perfectly willing to have a committee appointed for immediate investigation of the subject, and was equally willing to abide by the decision of such a committee with reference to the particular matter under consideration after a careful examination as to the effects of a faintly alkaline solution as compared with the solution now prescribed in the method.

Mr. Kedzie said that the whole question needed, as Mr. Frear had said, some investigation. If he might be allowed to be a little out of order, he would say that chemists who had tested the neutrality of the solution by coralline would find that if it was neutral by coralline it was alkaline by litmus or cochineal. He thought it would be well to let the matter lie over for another year and obtain fuller information from the concurrent testimony of as large a number of chemists as possible before taking final action in regard to it. He moved that the whole subject of the time of digestion and the nature of the citrate solution be referred to the reporter on phosphoric acid, who should invite as many chemists as possible to investigate the matter and make returns thereon. Carried.

Mr. Burney said that it would be seen from the tables that a great

many of the chemists had not used the official method in neutralizing the ammonium citrate solution; numbers of them had used litmus paper which seemed to have been prepared by Squibb. He had repeatedly tested the matter of neutralization and had found that when ordinary litmus paper indicated that the solution was neutral the coralline gave an acid indication, and if to a solution made neutral by means of litmus paper a bit of either ammonium carbonate or sodium carbonate was added there would be an evolution of gas, clearly indicating that the solution was still acid. Therefore the litmus paper could not be trusted and coralline should be insisted upon.

Mr. Gascoyne moved that in the method for citrate insoluble phosphoric acid (page 225) the words *ordinary temperature* be stricken out and that the words "about the temperature of 65°" be inserted in the place thereof, so changing the method as to direct that the precipitate be washed with hot water instead of cold water. Carried; and on motion the method for citrate insoluble phosphoric acid (pages 224, 225), as amended, was adopted.

By several motions, which were carried, the methods prescribed in 1889 (page 225) for total phosphoric acid and citrate-soluble phosphoric acid were readopted without change.

The president said that the preparation of reagents necessarily followed the methods adopted, and required no separate action. Instructions to the reporter would now be in order.

Mr. Battle moved that the reporter be instructed to ask the analysts to compare different methods for total phosphoric acid as to their results on commercial fertilizers, especially those containing organic matter of any kind. Seconded.

Mr. Burney moved to amend the motion by including in the methods directed to be compared the one described by him last year, and set forth on page 98 of the bulletin.

Mr. Burney accepted the amendment and the motion was carried.

Mr. Gibson moved that the reporter be instructed to ask the chemists to compare the Joulie method in so far as to digest in a strong alkaline solution, cold, for one hour, and then either estimate the available phosphoric acid in the ammonium citrate solution as pyrophosphate of magnesia or estimate the insoluble phosphoric acid by molybdenum and magnesia, as at present. Carried.

Mr. Gascoyne moved that the reporter be requested to send out as one of the samples either the aluminic phosphate or the phosphate manufactured by the Keystone Chemical Company. Carried.

On motion, the methods for determining phosphoric acid and moisture, as reported in 1889 (pages 224-226), and as amended, were adopted.

Mr. Wiley presented the following report:

REPORT OF COMMITTEE ON NATIONAL CHEMICAL SOCIETY.

GENTLEMEN: Your committee respectfully reports that it has conferred with a similar committee on the part of Section C of the A. A. A. S., and suggests that a committee of five be appointed by this association to coöperate with similar committees on the part of Section C, A. A. A. S., the Washington Chemical Society, and similar bodies, in calling a conference of chemists at some central point during the coming winter to consider the best means of organizing such a society.

H. W. WILEY.

W. C. STUBBS.

It was moved that the report be adopted. Carried.

Upon invitation by the president, Mr. Von Schweinitz exhibited some guinea pigs, and made the following statement:

In the interest of the Bureau of Animal Industry, Department of Agriculture, I have recently been making a study of the chemical products formed by the growth of the hog-cholera bacillus in artificial culture media. The bacteriological side of the question has, as most of you know, been very thoroughly worked out by Drs. Salmon and Smith, of the Bureau. After considerable trouble we succeeded in finding a medium that would yield the ptomaine in considerable quantity, and from these liquids, by adopting some modifications of Brieger's methods, I have succeeded in isolating an albuminoid body, which has been named *sucholo-albumin*, and an alkaloidal substance, or ptomaine, which I have called *sucholotoxin*.

We have gone a step further, and have succeeded in producing immunity in guinea pigs from hog cholera by previously injecting beneath the skin of the thigh different quantities of a solution of the *sucholo-albumin* or *sucholotoxin*, or both. The checks, pigs that were given the same sized dose of virus at the same time as the treated animals, invariably died, while the treated animals were but slightly affected by the virus, and recovered thoroughly, complete immunity being therefore produced.

The line of research is being continued; the experiments are being tried upon a large scale with guinea pigs and also upon hogs.

The guinea pigs which you see here are some of those which have been treated and then inoculated with hog cholera, and recovered; so you have before you a practical proof of the statements just made.

The president said that the report on fermented liquors, by Mr. Rising, was now in order.

Mr. Wiley said that as Mr. Rising had made a special trip to Europe to investigate the subject, and as he made no recommendations except that the method be continued as at present for next year, that he might have time to collate his report, and as he was reappointed, it might be well to simply read the communication by title and refer it to the printed proceedings.

Mr. Kedzie moved that Mr. Rising's communication be accepted and referred as suggested. Carried.

The communication here follows:

BERLIN, August 12, 1890.

Prof. H. W. WILEY,

Secretary A. O. A. C.:

DEAR SIR: Upon reaching this city I received a note from the president of the Association of Official Agricultural Chemists, containing the announcement that the meeting of the association will take place in August. I had counted upon having till September to finish my report, and expected to have been present at the meeting.

This is now impossible for several reasons. First, I have taken my passage from Liverpool for the 30th of August, and, second, I have business engagements which will detain me till that time whether I will or not. It is a matter of the greatest regret that I shall be obliged to forego the pleasure of meeting the members of the association at that time. It had not occurred to me that an earlier date would be set for the meeting, and consequently I am not able to give so complete a report as I had hoped to. The matter is made quite simple, because an agreement has practically been reached by German chemists which has my hearty indorsement. I have spent a good deal of time in getting the views of the leading chemists upon the important points connected with the various methods of analysis.

I spent some time in the municipal laboratory of Paris, met Mr. J. de Brevans, the chief chemist and discussed the subject with him. I visited Professor Fresenius and met his son, Dr. W. Fresenius and Dr. Borgemann. The meeting of the Bavarian chemists had taken place in May, so I could not attend it as I had hoped, but learned from those who were present the conclusions reached, and heard, "second hand," something of the discussion. I also visited Professor Rössler in Klosterneuburg bei Wien; Dr. Kayser, in Nuremberg, and Professor Hilger, in Erlangen, and others. Professor Hilger was kind enough to send me the resolutions of the Bavarian chemists, so that I think I am well informed in regard to methods in use here. I ought to say that I have been in close connection with my old teacher, Prof. von Hofmann, and Dr. Sell, now the chief chemist of the Gesundheits Amt. It will be of interest to the convention to hear that I have heard many appreciative words said about their work, by prominent chemists in Germany and elsewhere.

In regard to wine analysis I can only say that, by a general agreement, the conclusions adopted by the commission for the imperial health bureau (Gesundheits Amt) are universally adopted in Germany. The Bavarian chemists now work according to those methods. I will add the following suggestions to the paragraphs in last year's report.

Chemists here insist upon 15° instead of 25° as the better temperature for determining the specific gravity. Some were disposed to compromise on 20° , but I have found no one who was willing to adopt a higher temperature. It is very desirable to have all wine analyses made according to single standard, and then the results can be compared. I leave this, however, to the convention.

Extract evaporated to sirupy consistency on the water bath and then dried two and one-half hours at 100° in drying oven. (Drying to a constant loss is abandoned. My experience leads me most decidedly to this conclusion.)

In the glycerine determination the correction in (3) for the volatility of the glycerine is given up. According to experiments of Hehner it can be neglected.

The rest of the method can remain as in last year's report. I think perhaps it would be as well to omit what I added in regard to abnormal constituents. This is so special, and only one of many special methods to be used for abnormal wines, that my present judgment is that it would be better to omit it. The method of beer analysis, I think, may remain unchanged.

I wish to leave the report open to the suggestions and modifications of Drs. Crampton and Richards, based upon the analyses which they have made.

The interpretation to be given to the results of the chemical analysis of wines is a subject for special study and investigation; and this must be done for each country and district. It is only after we have ascertained by a large number of analyses what the constitution of the normal wine is that we can make comparisons.

In addition we have to fix limits for the amount of acid which may be contained in a good wine (including the amount of volatile acid). It may take some years yet to settle all of these points for the whole country, yet I look forward to a year of work which will go far toward establishing a standard or at least some approach toward a standard.

I have the honor to be, very truly, your reporter,

W. B. RISING.

The president nominated as a committee to confer with other committees in regard to a national chemical society Messrs. Wiley, Stubbs, Caldwell, Frear, and Nicholson.

It was moved that the executive committee be requested to appoint a time for next year's meeting following very closely or immediately the meeting of the American Association for the Advancement of Science, to be held in Washington if it be found feasible to do so. Carried.

On motion, adjourned.

**OFFICERS, REPORTERS, AND COMMITTEES OF THE ASSOCIATION OF
OFFICIAL AGRICULTURAL CHEMISTS OF THE UNITED STATES
FOR 1890-'91.**

PRESIDENT.

Mr. G. C. CALDWELL, chemist of the New York Agricultural Experiment Station.

VICE PRESIDENT.

Mr. N. T. LUPTON, vice director and chemist of the Alabama Experiment Station, and
official chemist of the Alabama State Department of Agriculture.

SECRETARY.

Mr. H. W. WILEY, chief chemist, United States Department of Agriculture.

EXECUTIVE COMMITTEE.

The **PRESIDENT**, **VICE PRESIDENT**, and **SECRETARY**, *ex-officio*,
MESSRS. E. B. VOORHEES, of New Brunswick, N. J.,
R. C. KEDZIE, of Lansing, Mich.

REPORTERS.

Ash and soil.—**Mr. R. C. Kedzie**, of Lansing, Mich.

Dairy products.—**Mr. W. W. Cooke**, of Burlington, Vt.

Foods and feeding stuffs, high in carbohydrates (foods, grains, and their milling products, etc.). — **Mr. Aug. E. Knorr**, of Washington, D. C.

Foods and feeding stuffs, low in carbohydrates (coarse fodders, oil-seed residues, etc.).—

Mr. Charles D. Woods, of Middletown, Conn.

Fermented liquors.—**Mr. W. B. Rising**, of Berkeley, Cal.

Nitrogen.—**Mr. William Frear**, of State College, Pa.

Phosphoric acid.—**Mr. H. A. Huston**, of La Fayette, Ind.

Potash.—**Mr. H. B. Battle**, of Raleigh, N. C.

Sugar.—**Mr. William C. Stubbs**, of Audubon Park, New Orleans, La.

COMMITTEES.

On National Chemical Society.—**Messrs. H. W. Wiley**, **W. C. Stubbs**, **G. C. Caldwell**,
William Frear, and **H. H. Nicholson**.

On ways and means for securing more thorough chemical study of foods and feeding stuffs. —
Messrs. W. O. Atwater, **G. C. Caldwell**, **E. H. Jenkins**, **W. H. Jordan**, and **H. W. Wiley**.

On chemical exhibit at the Chicago Columbian Exposition.—**Messrs. H. W. Wiley**, **Norman Robinson**, and **W. O. Atwater**.

CONSTITUTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

(1) This association shall be known as the Association of Official Agricultural Chemists of the United States. The objects shall be (1) to secure uniformity and accuracy of the methods, results, and modes of statements of analysis of fertilizers, soils, cattle foods,* dairy products, and other materials connected with agricultural industry; (2) to afford opportunity for the discussion of matters of interest to agricultural chemists.

(2) Analytical chemists connected with the United States Department of Agriculture, or with any State or national agricultural experiment station or agricultural college, or with any State or national institution or body charged with official control of the materials named in section 1, shall alone be eligible to membership, and one such representative for each of these institutions or boards, when properly accredited, shall be entitled to vote in the association. Only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers. Any person eligible to membership may become a member at any meeting of the association by presenting proper credentials and signing this constitution. All members of the association who lose their right to such membership by retiring from positions indicated as requisite for membership shall be entitled to become honorary members and to all privileges of membership save the right to hold office and vote. All analytical chemists and others interested in the objects of the association may attend its meetings and take part in its discussions, but shall have no vote in the association.

(3) The officers of the association shall consist of a president, vice-president, and secretary, who shall also officiate as treasurer; and these officers, together with two other members to be elected by the association, shall constitute the executive committee. When any officer ceases to be a member by reason of withdrawing from a department or board whose members are eligible to membership, his office shall be considered vacant, and a successor may be appointed by the executive committee to continue in office till the annual meeting next following.

(4) There shall be appointed by the president, at the regular annual meeting, a reporter for each of the subjects to be considered by the association.

It shall be the duty of these reporters to prepare and distribute samples and standard reagents to members of the association and others desiring the same; to furnish blanks for tabulating analyses, and to present at the annual meeting the results of work done, discussion thereof, and recommendations of methods to be followed.

(5) The special duties of the officers of the association shall be further defined, when necessary, by the executive committee.

* By a vote of the association, August 30, 1890, the subject of cattle foods was divided into two heads, namely, foods and feeding stuffs. It was understood by the latter of these divisions to include all fodders and feeding materials poor in starch and rich in fiber.

(6) The annual meeting of this association shall be held at such place as shall be decided by the association, and at such time as shall be decided by the executive committee, and announced at least three months before the time of meeting.

(7) Special meetings shall be called by the executive committee when in its judgment it shall be necessary, or on the written request of five members; and at any meeting, regular or special, seven enrolled members entitled to vote shall constitute a quorum for the transaction of business.

(8) The executive committee shall confer with the official boards represented with reference to the payment of expenses connected with the meetings and publication of the proceedings of the association.

(9) All proposed alterations or amendments to this constitution shall be referred to a select committee of three at a regular meeting, and after report from such committee may be adopted by a vote of two-thirds of the members present and entitled to vote.

OFFICIAL METHODS OF ANALYSIS OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS FOR 1890-'91.*

METHODS FOR THE DETERMINATION OF NITROGEN.

THE ABSOLUTE OR CUPRIC OXIDE METHOD.

[Applicable to all nitrogen determinations.]

The apparatus and reagents needed are as follows :

APPARATUS.

Combustion tube of best hard Bohemian glass, about 26 inches long and one-half inch internal diameter.

Azotometer of at least 100 cubic centimeters capacity, accurately calibrated.

Sprengel mercury air-pump.

Small paper scoop, easily made from stiff writing paper.

REAGENTS.

Cupric oxide (coarse).—Wire form ; to be ignited and cooled before using.

Fine cupric oxide.—Prepared by pounding ordinary cupric oxide in mortar.

Metallic copper.—Granulated copper or fine copper gauze reduced and cooled in stream of hydrogen.

Sodium bicarbonate.—Free from organic matter.

Caustic potash solution.—Dissolve commercial stick potash in less than its weight of water so that crystals are deposited on cooling. When absorption of carbonic acid ceases to be prompt solution must be discarded.

LOADING TUBE.

Of ordinary commercial fertilizers take 1 to 2 grams for analysis. In the case of highly nitrogenic substances the amount to be taken must be regulated by the amount of nitrogen estimated to be present. Fill tube as follows : (1) about 2 inches of coarse cupric oxide. (2) Place on the small paper scoop enough of the fine cupric oxide to fill, after having been mixed with the substance to be analyzed, about 4 inches of the tube; pour on this the substance, rinsing watch glass with a little of the fine oxide, and mix thoroughly with spatula; pour into tube, rinsing the scoop with a little fine oxide. (3) About 12 inches of coarse cupric oxide. (4) About 3 inches of metallic copper. (5) About $2\frac{1}{2}$ inches of coarse cupric oxide (anterior

* NOTE BY SECRETARY.—It was made the duty of the several reporters to prepare the methods of analysis as adopted by the association for editing by the secretary, the reporters being held responsible for the proper form of the text. All the reporters complied with this provision with the exception of Messrs. Jenkins and Burney. Mr. Jenkins did not attend the meeting. Mr. Burney did not forward any amended report of methods of analysis. The secretary has therefore changed the methods for dairy products and phosphoric acid as they appear to be ordered in the text of the proceedings.

layer). (6) Small plug of asbestos. (7) Eight-tenths to 1 gram of sodium bicarbonate. (8) Large, loose plug of asbestos; place tube in furnace, leaving about 1 inch of it projecting; connect with pump by rubber stopper smeared with glycerine, taking care to make connection perfectly tight.

OPERATION.

Exhaust air from tube by means of pump. When a vacuum has been obtained allow flow of mercury to continue, light gas under that part of the tube containing metallic copper, anterior layer of cupric oxide (see 5th above) and bicarbonate of soda. As soon as vacuum is destroyed and apparatus filled with carbonic acid gas, shut off the flow of mercury and at once introduce the delivery tube of the pump into the receiving arm of the azotometer, and just below the surface of the mercury seal of the azotometer, so that the escaping bubbles will pass into the air and not into the azotometer, thus avoiding the useless saturation of the caustic potash solution.

When the flow of carbonic acid has very nearly or completely ceased, pass the delivery tube down into the receiving arm so that the bubbles will escape into the azotometer. Light the jets under the 12-inch layer of oxide, heat gently for a few moments to drive out any moisture that may be present, and bring to red heat. Heat gradually mixture of substance and oxide, lighting one jet at a time. Avoid too rapid evolution of bubbles, which should be allowed to escape at rate of about one per second or a little faster.

When the jets under mixture have all been turned on light jets under layer of oxide at end of tube. When evolution of gas has ceased turn out all the lights except those under the metallic copper and anterior layer of oxide, and allow to cool for a few moments. Exhaust with pump and remove azotometer before flow of mercury is stopped. Break connection of tube with pump, stop flow of mercury, and extinguish lights. Allow azotometer to stand for at least an hour or cool with stream of water until permanent volume and temperature are reached.

Adjust accurately the level of the KOH solution in bulb to that in azotometer, note volume of gas, temperature, and height of barometer; make calculations as usual. The labor of calculation may be much diminished by the use of the tables prepared by Messrs. Battle and Dancy, of the North Carolina Experiment Station (Raleigh, N. C.).

The above details are, with some modifications, those given in the report of the Connecticut Station for 1879 (p. 124), which may be consulted for details of apparatus, should such details be desired.

THE KJELDAHL METHOD.

[Not applicable in presence of nitrates.]

APPARATUS AND REAGENTS.

(1) Standard hydrochloric acid whose absolute strength has been determined: (a) By precipitating with silver nitrate and weighing the silver chloride as described in Crook's Select Methods, page 571; (b) by potassium tetra-oxalate which has been purified by recrystallizing two or three times; (c) by determining the amount neutralized by the distillate from a weighed quantity of pure ammonium chloride boiled with an excess of sodium hydrate. Half normal acid, *i. e.*, containing 18.23 grams hydrochloric acid to the liter, is recommended. Cochineal or dimethyl-aniline orange to be used as the indicator in standardizing the acid.

(2) Standard ammonia whose strength, relative to the acid, has been accurately determined. One-tenth normal ammonia, *i. e.*, containing 0.7 gram ammonia to the liter, is recommended for accurate work.

(3) "C. P." Sulphuric acid, specific gravity 1.83, free from nitrates and also from

ammonia sulphate, which is sometimes added in the process of manufacture to destroy oxides of nitrogen. Eimer & Amend's "Strictly C. P." is good.

(4) Metallic mercury or mercuric oxide, HgO , prepared in the wet way. That prepared from mercury nitrate can not safely be used.

(5) Potassium permanganate tolerably finely pulverized.

(6) Granulated zinc, pumice stone, or one-half a gram of zinc dust to be added to the contents of the flasks in distillation, when found necessary in order to keep from bumping.

(7) A solution of 40 grams of commercial potassium sulphide in 1 liter of water.

(8) A saturated solution of sodium hydrate free from nitrates, which are sometimes added in the process of manufacture to destroy organic matter and improve the color of the product. That of the Greenbank Alkali Company is of good quality.

(9) Solution of cochineal prepared according to Fresenius's Quantitative Analysis, second American edition, page 679.

(10) Kjeldahl digestion flasks of hard, moderately thick, well-annealed glass. These flasks are about 9 inches long, with a round, pear-shaped bottom, having a maximum diameter of $2\frac{1}{2}$ inches, and tapering out gradually in a long neck, which is three-fourths of an inch in diameter at the narrowest part, and flared a little at the edge. The total capacity is 225 to 250 cubic centimeters.

(11) Distillation flasks of ordinary shape, of 550 cubic centimeters capacity, or preferably flasks of the same capacity, of pear-shaped bottom, of well-annealed glass, for both digestion and distillation, and fitted with a rubber stopper and a bulb tube above to prevent the possibility of sodium hydrate being carried over mechanically during distillation. The bulbs are about $1\frac{1}{2}$ inches in diameter, the tubes being the same diameter as the condenser and cut off obliquely at the lower end. This is adjusted to the tube of the condenser by a rubber tube.

(12) *A condenser.*—Several forms have been described, no one of which is equally convenient for all laboratories. The essential thing is that the tube which carries the steam to be condensed shall be of block-tin. The upper ends of the tin tubes should be bent so that the glass connections may have a slope toward the distilling flasks. All kinds of glass are decomposed by steam and ammonia vapor, and will give up alkali enough to impair accuracy. (See Kreussler and Henzold, Ber. Berichte, XVII, 34.) The condenser in use in the laboratory of the Connecticut Experiment Station, devised by Professor Johnson, consists of a copper tank, supported by a wooden frame, so that its bottom is 11 inches above the work-bench on which it stands. This tank is 16 inches high, 32 inches long, and 3 inches wide from front to back, widening above to 6 inches. It is provided with a water-supply tube, which goes to the bottom, and a larger overflow pipe above. The block-tin condensing tubes, whose external diameter is three-eighths of an inch, seven in number, enter the tank through holes in the front side of it near the top, above the level of the overflow, and pass down perpendicularly through the tank and out through rubber stoppers tightly fitted into holes in the bottom. They project about $1\frac{1}{2}$ inches below the bottom of the tank, and are connected by short rubber tubes with glass bulb tubes of the usual shape, which dip into precipitating beakers or Erlenmeyer flasks of about 300 cubic centimeters capacity. The titration can be made directly in them. The distillation flasks are supported on a sheet-iron shelf, attached to the wooden frame that supports the tanks in front of the latter. Where each flask is to stand a circular hole is cut, with three projecting lips, which support the wire gauze or asbestos under the flask, and three other lips, which hold the flask in place and prevent its moving laterally out of place while distillation is going on. Below this sheet-iron shelf is a metal tube carrying seven Bunsen burners, each with a stop-cock like those of a gas-combustion furnace. These burners are of a larger diameter at the top, which prevents smoking when covered with fine gauze to prevent the flame from striking back.

(13) The stand for holding the digestion flasks consists of a pan of sheet-iron 29 inches long by 8 inches wide, on the front of which is fastened a shelf of sheet-iron as

long as the pan, 5 inches wide and 4 inches high. In this are cut six holes $1\frac{1}{8}$ inches in diameter. At the back of the pan is a stout wire running lengthwise of the stand, 8 inches high, with a bend or depression opposite each hole in the shelf. The digestion flask rests with its lower part over a hole in the shelf and its neck in one of the depressions in the wire frame, which holds it securely in position. Heat is supplied by low Bunsen burners below the shelf. With a little care the naked flame can be applied directly to the flask without danger.

THE DETERMINATION.

(1) *The digestion.*—Seven-tenths to 2.8 grams of the substance to be analyzed, according to its proportion of nitrogen, is brought into a digestion flask with approximately 0.7 gram of mercuric oxide, or its equivalent in metallic mercury, and 20 cubic centimeters of sulphuric acid. The flask is placed on the frame above described, in an inclined position, and heated below the boiling point of the acid for from five to fifteen minutes, or until frothing has ceased. If the mixture froths badly, a small piece of paraffine may be added to prevent it. The heat is then raised until the acid boils briskly. No further attention is required till the contents of the flask have become a clear liquid, which is colorless, or at least has only a very pale straw color. The flask is then removed from the frame, held upright, and, while still hot, potassium permanganate is dropped in carefully and in small quantity at a time till, after shaking, the liquid remains of a green or purple color.

(2) *The distillation.*—After cooling, the contents of the flask are transferred to the distilling flask with about 200 cubic centimeters of water, and to this a few pieces of granulated zinc, pumice stone, or one-half gram of zinc dust when found necessary to keep the contents of the flask from bumping, and 25 cubic centimeters of potassium sulphide solution are added, shaking the flask to mix its contents. Next add 50 cubic centimeters of the soda solution or sufficient to make the reaction strongly alkaline, pouring it down the side of the flask so that it does not mix at once with the acid solution. Connect the flask with the condenser, mix the contents by shaking, and distill until all ammonia has passed over into the standard acid. The first 150 cubic centimeters of the distillate will generally contain all of the ammonia. This operation usually requires from forty minutes to one hour and a half. The distillate is then titrated with standard ammonia.

The use of mercuric oxide in this operation greatly shortens the time necessary for digestion, which is rarely over an hour and a half in cases of substances most difficult to oxidize, and is more commonly less than an hour. In most cases the use of potassium permanganate is quite unnecessary, but it is believed that in exceptional cases it is required for complete oxidation, and in view of the uncertainty it is always used. Potassium sulphide removes all mercury from solution, and so prevents the formation of mercurio-ammonium compounds which are not completely decomposed by soda solution. The addition of zinc gives rise to an evolution of hydrogen and prevents violent bumping. Previous to use the reagents should be tested by a blank experiment with sugar, which will partially reduce any nitrates that are present which might otherwise escape notice.

KJELDAHL METHOD MODIFIED TO INCLUDE THE NITROGEN OF NITRATES.*

[Applicable to all fertilizers containing nitrates.]

Besides the reagents and apparatus given under the Kjeldahl method there will be needed—

- (1) Zinc dust. This should be an impalpable powder; granulated zinc or zinc filings will not answer.
- (2) Zinc sulphide.
- (3) Commercial salicylic acid.

* Described by Prof. M. A. Scovell.

THE DETERMINATION.

Bring from 0.7 to 1.4 grams of the substance to be analyzed into a Kjeldahl digesting flask, add to this 30 cubic centimeters of sulphuric acid containing 2 grams of salicylic acid, and shake thoroughly; then add *gradually* 2 grams of zinc dust, shaking the contents of the flask at the same time, or add to substance 30 cubic centimeters of sulphuric acid containing 1 gram of salicylic acid; then add direct 2 grams of zinc sulphide. Finally place the flask on the stand for holding the digestion flasks, where it is heated over a low flame until all danger from frothing has passed. The heat is then raised until the acid boils briskly, and the boiling continued until white fumes no longer pour out of the flask. This requires about five or ten minutes. Add now approximately 0.7 gram mercuric oxide, or its equivalent in metallic mercury, and continue the boiling until the liquid in the flask is colorless, or nearly so. (In case the contents of the flask are likely to become solid before this point is reached, add 10 cubic centimeters more of sulphuric acid.) Complete the oxidation with a little permanganate of potash in the usual way, and proceed with the distillation as described in the Kjeldahl method. The reagents should be tested by blank experiments.

THE RUFFLE METHOD.

APPARATUS AND REAGENTS.

- (1) Standard solutions and indicator the same as for the Kjeldahl method.
- (2) A mixture of equal parts by weight of fine slaked lime and finely powdered crystallized sodium hyposulphite.
- (3) A mixture of equal parts by weight of finely powdered granulated sugar and flowers of sulphur.
- (4) Granulated soda lime, as described under the soda-lime method.
- (5) Combustion tubes of hard Bohemian glass, 20 inches long and $\frac{1}{2}$ inch in diameter.
- (6) Bulbed "U" tubes or Will's bulbs, as described under the soda-lime method.

PREPARATION.

- (1) Clean and fill the U tube with 10 cubic centimeters of standard acid.
- (2) Fit cork and glass connecting tube. Fill the tube as follows: (1) A loosely fitting plug of asbestos, previously ignited, and then 1 to $1\frac{1}{2}$ inches of the hyposulphite mixture. (2) The weighed portion of the substance to be analyzed is intimately mixed with from 5 to 10 grams of the sugar and sulphur mixture. (3) Pour on a piece of glazed paper, or porcelain mortar, a sufficient quantity of the hyposulphite mixture to fill about 10 inches of the tube; then add the substance to be analyzed, as previously prepared; mix carefully and pour into the tube; shake down the contents of the tube; rinse off the paper or mortar with a small quantity of the hyposulphite mixture and pour into the tube; then fill up with soda lime to within 2 inches of the end of the tube. (4) Place another plug of ignited asbestos at the end of the tube and close with a cork. (5) Hold the tube in a horizontal position, and tap on the table until there is a gas channel all along the top of the tube. Make connection with the U tube containing the acid, aspirate, and see that the apparatus is tight.

The combustion.—Place the prepared combustion tube in the furnace, letting the open end project a little so as not to burn the cork. Commence by heating the soda-lime portion until it is brought to a full red heat. Then turn on slowly jet after jet toward the outer end of the tube, so that the bubbles come off two or three a second. When the whole tube is red hot and the evolution of the gas has ceased and the liquid in the U tube begins to recede toward the furnace attach the aspirator to the other limb of the U tube, break off the end of the tube, and draw a current of air through for a few minutes. Detach the U tube and wash the contents into a beaker or porcelain basin, add a few drops of the cochineal solution, and titrate.

THE SODA-LIME METHOD.

[Not applicable in presence of nitrates.]

APPARATUS AND REAGENTS.

- (1) Standard solutions and indicator the same as for the Kjeldahl method.
- (2) Granulated soda lime, fine enough to pass a 10-mesh sieve, and thoroughly dry.
- (3) Fine soda lime, fine enough to pass a 20-mesh sieve, also thoroughly dry.

To prepare soda lime of the required fineness, the coarse granulated article of the trade may be ground until it will pass through a sieve of about ten-hundredths inch mesh. It is then sifted on a sieve of about twenty-hundredths inch mesh to separate the fine from the coarse. The two portions are then thoroughly dried in the air bath, or by heating in a porcelain dish or iron pan over a lamp, stirring constantly.

Excellent soda lime may be easily and cheaply prepared according to the directions of Professor Atwater (*Am. Chem. Journal*, vol. 9, p. 312), by slaking $2\frac{1}{4}$ parts of quicklime with a strong solution of 1 part commercial caustic soda (such soda as is used in the Kjeldahl process), care being taken that there is enough water in the solution to slake the lime. The mixture is then dried and heated in an iron pot to incipient fusion, and when cold ground and sifted as above.

Instead of soda lime, Johnson's mixture of carbonate of soda and lime or slaked lime may be used.

Slaked lime may be granulated by mixing it with a little water to form a thick mass, which is dried in the water oven until hard and brittle. It is then ground and sifted as above. Slaked lime is much easier to work with than soda lime and gives excellent results, though it is probable that more of it should be used in proportion to the substance to be analyzed than is the case with soda lime.

- (4) Asbestos which has been ignited and kept in a glass-stoppered bottle.
- (5) Combustion tubes about 40 centimeters long and about 12 millimeters internal diameter drawn out to a point and closed at one end.
- (6) Large-bulbed "U" tubes with glass stop-cock or Will's tubes with four bulbs.

THE DETERMINATION.

The substance to be analyzed should be powdered fine enough to pass through a sieve of 1 millimeter mesh; 0.7 to 1.4 grams, according to the amount of nitrogen present, is taken for the determination. Into the closed end of the combustion tube put a small loose plug of asbestos, and upon it about 4 centimeters of fine soda lime. In a porcelain dish or mortar mix the substance to be analyzed thoroughly, but quickly, with enough fine soda lime to fill about 16 centimeters of the tube, or about 40 times as much soda lime as substance, and put the mixture into the combustion tube as quickly as possible by means of a wide-necked funnel, rinsing out the dish and funnel with a little more fine soda lime, which is to be put in on top of the mixture. Fill the rest of the tube to about 5 centimeters of the end with a granulated lime, making it as compact as possible by tapping the tube gently while held in a nearly upright position during the filling. The layer of granulated soda-lime should be not less than 12 centimeters long. Lastly, put in a plug of asbestos about 2 centimeters long, pressed rather tightly, and wipe out the end of the tube, to free it from adhering soda lime.

Connect the tube by means of a well-fitting rubber stopper or cork with the "U" tube or Will's bulbs containing 10 cubic centimeters standard acid, and adjust it in the combustion furnace so that the end projects about 4 centimeters from the furnace, supporting the "U" tube or Will's bulb suitably. Heat the portion of the tube containing the granulated soda lime to moderate redness, and when this is attained extend the heat gradually through the portion containing the substance so as to keep up a moderate and regular flow of gases through the bulbs, maintaining the heat of

the first part until the whole tube is heated uniformly to the same degree. Keep up the heat until gases have ceased bubbling through the acid in the bulbs and the mixture of substance and soda lime has become white or nearly so, which shows that the combustion is finished. The combustion should occupy about three-quarters of an hour, or not more than one hour. Remove the heat, and when the tube has cooled below redness break off the closed tip and aspirate air slowly through the apparatus for two or three minutes to bring all the ammonia into the acid. Disconnect, wash the acid into a beaker or flask, and titrate with the standard alkali.

During the combustion the end of the tube projecting from the furnace must be kept heated sufficiently to prevent the condensation of moisture, yet not enough to char the stopper. The heat may be regulated by a shield of tin slipped over the projecting end of the combustion tube.

It is found very advantageous to attach a Bunsen valve to the exit tube, allowing the evolved gases to pass out freely, but preventing a violent "sucking back" in case of a sudden condensation of steam in the bulbs.

METHODS OF ANALYSIS OF DAIRY PRODUCTS.

BUTTER.

MICROSCOPIC EXAMINATION.

Place a small portion of the fresh sample taken from the inside of the mass on a slide, add a drop of pure sweet oil, cover with gentle pressure, and examine with a one-half to one-eighth inch objective for crystals of lard, etc.

Examine same specimen with polarized light and selenite plate without the use of oil.

Pure fresh butter will neither show crystals nor a parti-colored field with selenite. Other fats melted and cooled and mixed with butter will usually present crystals and variegated colors with the selenite plate.

For further microscopic study dissolve 4 or 5 cubic centimeters of the fat in 15 cubic centimeters of ether in a test tube. Stopper the tube with cotton wool loosely and allow to stand twelve to twenty-four hours at room temperature (20° to 25°). When crystals form at the bottom of the tube they are removed with a pipette or glass rod or tube, placed on a slide, covered, and examined. The crystals formed by later deposits may be examined in a similar way.

Sampling.—If large quantities of butter are to be sampled a butter trier or sampler may be used. The portions thus drawn, about 500 grams, are to be perfectly melted in a closed vessel at as low a heat as possible, and when melted the whole is to be shaken violently for some minutes till the mass is homogeneous. A portion is then poured into a vessel from which it is to be weighed out for analysis, and should nearly or quite fill it. This sample should be kept in a cold place till analyzed.

Determination of water.—1.5 to 2.5 grams are dried to constant weight at the temperature of boiling water in a dish with flat bottom, having a surface of at least 20 cm².

The use of clean, dry sand or asbestos with the butter is admissible, and is necessary if a dish with round bottom is employed.

Determination of fat.—The dry butter from the water determination is dissolved in the dish with *absolute* ether or with 76° benzine. The contents of the dish are then transferred to a weighed Gooch filter with the aid of a wash bottle filled with the solvent and are washed till free from fat. The crucible and contents are heated at the temperature of boiling water till the weight is constant. The weight of fat is calculated from the data obtained.

Substitute method for fat.—Water may be determined by drying the butter on asbestos or sand and the fat extracted by *anhydrous alcohol-free* ether in an extraction apparatus. The extract, after evaporation of the ether, is heated to constant weight at the temperature of boiling water and weighed.

Determination of casein and ash.—The crucible containing the residue from the fat determination, consisting of casein and ash, is covered and heated gently at first, gradually raising the temperature to just below red heat. The cover may then be removed and the heat continued till the contents of the crucible are white. The loss in weight of the crucible and contents represents casein, and the residue in the crucible, mineral matter. In this mineral matter, dissolved in water slightly acidulated, chlorine may be determined gravimetrically with silver nitrate, or volumetrically, using potassium chromate as indicator.

ESTIMATION OF SALT (NaCl).

Volumetric method.—The amount of the butter or butter substitute to be taken is from 5 to 10 grams; weigh in a counterpoised beaker-glass. The butter (fresh from the refrigerator) is placed in portions of about 1 gram at a time in the beaker, these portions being taken from different parts of the sample. By this means a reasonably fair sample of the whole is obtained.

The given quantity having been weighed out, it is removed from the pan.

Hot water is now added (about 20 cubic centimeters) to the beaker containing the butter, and after it has melted the liquid is poured into the bulb of the separating apparatus. The stopper is now inserted and the contents shaken for a few moments.

After standing until the fat has all collected on top of the water, the stop-cock is opened and the water, containing most of the salt, is allowed to run into an Erlenmeyer flask, being careful to let none of the fat globules pass.

Hot water is again added to the beaker and thence poured into the separatory apparatus, the bottle well shaken, and the foregoing process is repeated from ten to fifteen times, using each time 10 to 20 cubic centimeters of water.

The resulting washings contain all but a mere trace of the NaCl originally present in the butter.

Estimation of NaCl in filtrate.—The chloride of sodium is now determined in the filtrate by a standard solution of AgNO_3 , using a few drops of a saturated solution of potassium chromate as indicator.

SPECIFIC GRAVITY.

Weight of flask.—Use a small specific gravity flask of from 25 to 30 cubic centimeters capacity. The stopper should be beveled to a fine edge on top and the lower end should be slightly concave to avoid any trapping of air. The flask is to be thoroughly washed with hot water, alcohol, and ether, and then dried for thirty minutes to one hour at 100° . After cooling in a desiccator the weight of the flask and stopper is accurately determined.

Weight of water.—The flask in an appropriate holder (Fig. 16); conveniently made of galvanized iron, is filled with freshly boiled and still hot distilled water and placed in a bath of pure, very hot, distilled water in such a way that it is entirely surrounded by the liquid with the exception of the top.

The water of the bath is kept in brisk ebullition for thirty minutes, any evaporation from the flask being replaced by the addition of boiling distilled water. The stopper* is then inserted, the flask removed, wiped dry, and after it is nearly cooled to room temperature, placed in the balance and weighed when balance temperature is reached. A convenient size of holder will enable the analyst to use eight flasks at once. The temperature at which water boils in each locality may also be determined; but unless at very high altitudes or on days of unusual barometric disturbance the variations will not be great, and will not appreciably affect the results.

* The stopper should be kept for a few minutes before use in hot distilled water.

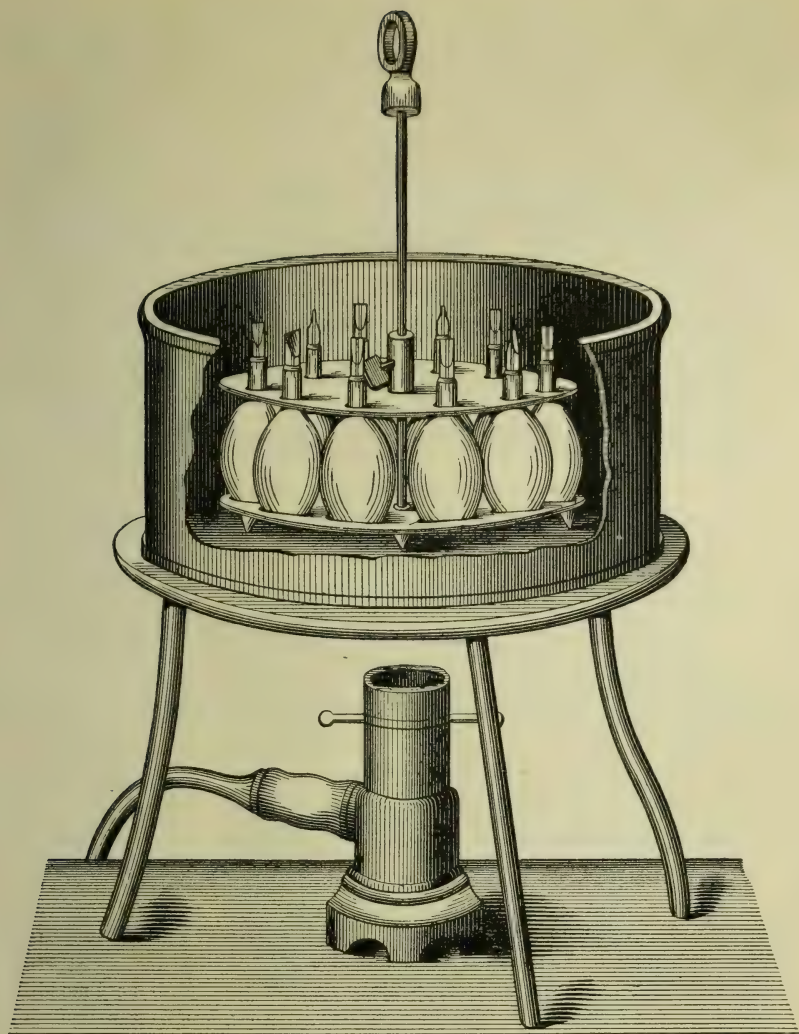


FIG. 16.

ALTERNATE METHOD OF ESTIMATING THE WEIGHT OF WATER IN FLASKS.

COMPUTATION BY THE FORMULA OF LANDOLT.

Formula for calculating volume V , in cubic centimeters, of a glass vessel from the weight P of water of temperature t contained therein, and the volume V' at any other temperature t' (from Landolt and Börnstein's Physical-Chemical tables, p. 39, table 17):

$$V = P \frac{p}{d}$$

$$V' = P \frac{p}{d} \left[1 + \gamma (t' - t) \right]$$

p = weight (in brass weights) of 1 cubic centimeter H_2O in vacuo; see formula table 3. (This is so nearly 1 that it will not affect the result in the fifth place of decimals and may therefore be disregarded.) Hence the formula stands:

$$V' = P \frac{1}{d} \left[1 + \gamma (t' - t) \right]$$

d = density of water at temperature t (see table 12).

γ = .000025, the cubical expansion coefficient of glass.

From this volume the weight of the water may be readily obtained by referring to tables 13 and 13a.

Weight of fat at water-boiling temperature.—The flask is emptied of its water, rinsed with alcohol and ether, and dried again for a few minutes at 100° . It is then filled with the dry, hot, fresh-filtered fat, which should be entirely free from air bubbles.

The stoppered flask is then replaced in the water bath, kept for thirty minutes at the temperature of boiling water, removed and treated as above. The weight of fat having been determined, the specific gravity is obtained by dividing it by the weight of water previously found.

Example.

	Grams.
Weight of flask No. 22, dry	10.0197
Weight of flask No. 22, plus water	37.3412
Weight of water	27.3215
Weight of flask No. 22, plus fat	34.6111
Weight of fat	24.5914

$$\text{Specific gravity} = 24.5914 \div 27.3215 = .90008.$$

The weight of the flask dry and empty and the weight of water at 99° to 100° contained therein may be used constantly if great care be taken in handling and cleaning the apparatus.

Example.

	Grams.
Weight of flask No. 10, dry and empty	10.0028
Weight of flask after three weeks' use	10.0030

MELTING POINT.

The apparatus for determining the melting point (shown in Fig. 17) consists of (1) an accurate thermometer for reading easily tenths of a degree; (2) a cathetometer for reading the thermometer (this may be done with an eyeglass, if held steadily and properly adjusted); (3) a thermometer; (4) a tall beaker glass, 35 centimeters high and 10 centimeters in diameter; (5) a test tube 30 centimeters long and 3.5 centimeters in diameter; (6) a stand for supporting the apparatus; (7) some method of stirring the water in the beaker, for example, a blowing bulb of rubber, and a bent glass tube extending to near the bottom of the beaker; (8) a mixture of alcohol and water of the same specific gravity as the fat to be examined.

MANIPULATION.

The disks of the fat are prepared as follows: The melted and filtered fat is allowed to fall from a dropping tube from a height of 15 to 20 centimeters onto a smooth piece of ice floating in water. The disks thus formed are from 1 to 1.5 centimeters in diameter and weigh about 200 milligrams. By pressing the ice under the water the disks are made to float on the surface, whence they are easily removed with a steel spatula, which should be cooled in the ice water before using.

The mixture of alcohol and water is prepared by boiling distilled water and 95 per cent alcohol for ten minutes to remove the gases which they may hold in solution. While still hot, the water is poured into the test tube already described until it is

nearly half full. The test tube is then nearly filled with the hot alcohol. It should be poured in gently down the side of the inclined tube to avoid too much mixing. If the tube is not filled until the water has cooled, the mixture will contain so many air bubbles as to be unfit for use. These bubbles will gather on the disk of fat as the temperature rises and finally force it to the top of the mixture.

The test tube containing the alcohol and water is placed in a tall beaker containing water and ice. The disk of fat is dropped into the tube from the spatula, and at once sinks until it reaches a part of the tube where the density of the alcohol-water is exactly equivalent to its own. Here it remains at rest and free from the action of any force save that inherent in its own molecules.

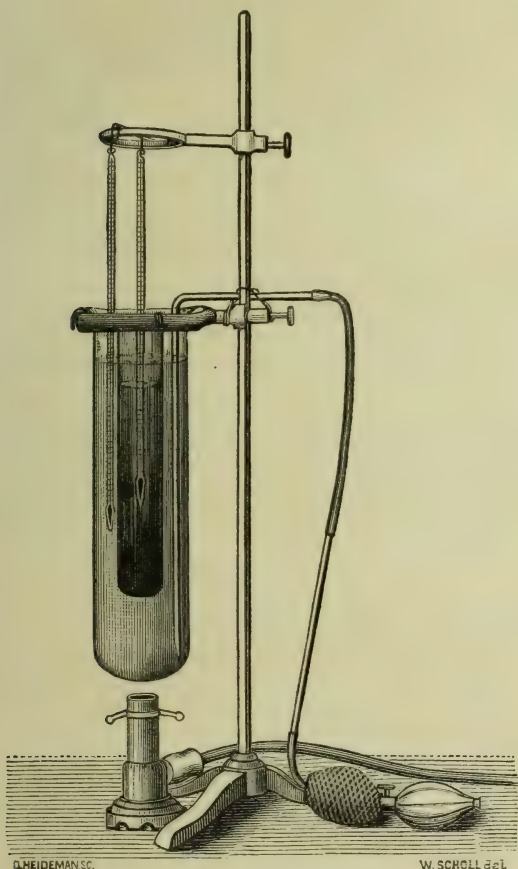


FIG. 17.

The delicate thermometer is placed in the test tube and lowered until the bulb is just above the disk. In order to secure an even temperature in all parts of the alcohol mixture in the vicinity of the disk the thermometer is moved from time to time in a circularly pendulous manner. A tube prepared in this way will be suitable for use for several days; in fact until the air bubbles begin to attach themselves to the disk of fat. In no case did the two liquids become so thoroughly mixed as to lose the property of holding the disk at a fixed point, even when they were kept for several weeks.

In practice, owing to the absorption of air, it has been found necessary to prepare new solutions every third or fourth day.

The disk having been placed in position, the water in the beaker glass is slowly heated and kept constantly stirred by means of the blowing apparatus already described.

When the temperature of the alcohol-water mixture rises to about 6° below the melting point the disk of fat begins to shrivel and gradually rolls up into an irregular mass.

The thermometer is now lowered until the fat particle is even with the center of the bulb. The bulb of the thermometer should be small, so as to indicate only the temperature of the mixture near the fat. A gentle rotary movement should be given to the thermometer bulb, which might be done with a kind of clock work. The rise of temperature should be so regulated that the last 2° of increment require about ten minutes. The mass of fat gradually approaches the form of a sphere, and when it is sensibly so the reading of the thermometer is to be made. As soon as the temperature is taken the test tube is removed from the bath and placed again in the cooler. A second tube, containing alcohol and water, is at once placed in the bath. The test tube (ice water being used as a cooler) is of low enough temperature to cool the bath sufficiently. After the first determination, which should be only a trial, the temperature of the bath should be so regulated as to reach a maximum about 1.5° above the melting point of the fat under examination.

Working thus with two tubes about three determinations can be made in an hour. After the test tube has been cooled the globule of fat is removed with a small cup attached to a wire before another disk of fat is put in.

The distilled water in which the piece of ice floats on which the disks are made should be recently boiled to free it of all air particles. It is important that the disks be free from air bubbles.

The edge of the disk should not be allowed to touch the sides of the tube. This accident rarely happens, but in case it should take place and the disk adhere to the sides of the tube a new trial should be made.

Triplicate determinations should be made and the second and third results should show a near agreement.

Example.

Melting point of sample of butter 6372 (No. 3):

	Degrees C.
(1)	33.15
(2)	33.05
(3)	33.00

ESTIMATION OF VOLATILE ACIDS.

REAGENTS.

SOLUTION OF CAUSTIC SODA.

1. 100 grams NaOH dissolved in 100 cubic centimeters pure water. The caustic soda should be as free as possible from carbonate and be preserved from contact with the air.

2. Alcohol, about 95 per cent redistilled with caustic soda.

3. Solution of sulphuric acid containing 25 cubic centimeters strongest H_2SO_4 in 1,000 cubic centimeters of water.

4. An accurately standardized approximately decinormal solution of barium hydrate.

5. Alcoholic solution of phenolphthalein.

APPARATUS.

1. Saponification flasks of hard, well-annealed glass, capable of resisting the tension of alcohol vapor at 100°C . The flask shown in Fig. 18 is most suitable for this purpose. It should have from 250 to 300 cubic centimeters capacity.

(a.) Instead of such a flask an Erlenmeyer flask of the same capacity fitted with long glass tube or reflux condenser may be used.

2. A pipette graduated to deliver 40 cubic centimeters.

3. Distilling apparatus as represented in Fig. 19. One with a smaller bulb tube may also be used.

4. An accurately calibrated burette reading to tenths of a cubic centimeter.

THE MANIPULATION.

Weighing the fat.—The butter or fat to be examined should be melted and kept in a dry warm place at about 60°C for two or three hours until the moisture and curd have entirely settled out. The clean supernatant fat is poured off and filtered through a dry filter paper in a jacketed filter containing boiling water, to remove all foreign matter and any traces of moisture. Should the filtered fat in a fused state not be perfectly clear the treatment above mentioned must be repeated.

The saponification flasks are prepared by having them thoroughly washed with water, alcohol, and ether, wiped perfectly dry on the outside and heated for one hour to 100°C (*circa*). The flasks should then be placed in a tray by the side of the balance and covered with a silk handkerchief until they are perfectly cool. They must not be wiped with a silk handkerchief within fifteen or twenty minutes of the time they are weighed. The weight of each flask is determined accurately, using a flask for a counterbalance or not, as may be convenient. The weight of the flasks having been accurately determined they are charged with the melted fat in the following way:

A pipette with a long stem marked to deliver 5.75 cubic centimeters is warmed to a temperature of about 50°C . The fat having been poured back and forth once or twice into a dry beaker in order to thoroughly mix it, it is taken up in the pipette, the nozzle of the pipette carried to near the bottom of the flask, it having been previously wiped to remove any adhering fat. The 5.75 cubic centimeters of fat are allowed to flow into the flask and the pipette is removed. After the flasks have been charged in this way they should be re-covered with the silk handkerchief and allowed to stand fifteen or twenty minutes, when they are again weighed.*

The saponification.—Ten cubic centimeters of 95 per cent alcohol redistilled from caustic soda are added to the fat in the flask, 2 cubic centimeters of the concentrated soda solution are added, a soft cork stopper inserted in the flask and tied down with a piece of twine. The saponification is then completed by placing the flasks upon the water or steam bath as indicated in Fig. 18. The flasks during the saponification, which should last for one hour, should be gently rotated from time to time, being careful not to project the soap for any distance up the sides of the flask. At the end of an hour the flasks, after having been cooled to near the room temperature, are opened.

Removal of the alcohol.—The stoppers having been laid loosely in the mouth of the flasks the alcohol is removed by dipping the flasks into a steam bath. The steam

* Before weighing the flasks any desiccating material used in the balance should be removed. If round bottom flasks are employed, a special form of holder must be used. This is made on the principle of a test tube rack, the lower board of the tray being perforated so as to receive the round bottom of the flask and being protected by lugs, so that on being placed on a table the bottoms of the flasks do not touch the table.

Example :

	Grams.
Weight of counterbalanced flask No. 3	22.5904
Weight of counterbalanced flask No. 3 + fat	27.6734
Weight of fat	5.0830

should cover the whole of the flask except the neck. After the alcohol is nearly removed frothing may be noticed in the soap, and to avoid any loss from this cause or any creeping of the soap up the sides of the flask it should be removed from the bath and shaken to and fro until the frothing disappears. The last traces of alcohol vapor may be removed from the flask by waving it briskly, mouth down, to and fro. Complete removal of the alcohol with the precautions above noted should take about forty-five minutes.

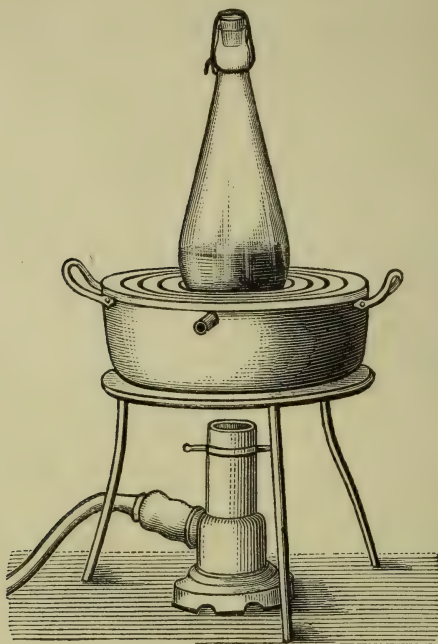


FIG. 18.

Dissolving the soap.—After the removal of the alcohol the soap should be dissolved by adding 100 cubic centimeters of recently boiled distilled water, and warmed on the steam bath with occasional shaking until the soap is completely dissolved.

Setting free the fatty acids.—When the soap solution has cooled to about 60° or 70° C the fatty acids are separated by adding 40 cubic centimeters of the dilute sulphuric acid solution mentioned above.

Melting the fatty acid emulsion.—The flasks should now be restoppered as in the first instance, and the fatty acid emulsion melted by replacing the flasks on the steam bath. According to the nature of the fat examined the time required for the fusion of the fatty acid emulsions may vary from a few minutes to hours.

The distillation.—After the fatty acids are completely melted, which can be determined by their forming a transparent oily layer on the surface of the water, the flasks are cooled to room temperature and a few pieces of pumice stone added. The pumice stone is prepared by throwing it, at white heat, into distilled water and keeping it under water until used. The flask is now connected with a condenser (Fig. 19) slowly heated with a naked flame until ebullition begins, and then the distillation continued by regulating the flame in such a way as to collect 110 cubic centimeters of the distillate in as nearly as possible thirty minutes. The distillate should be received in flasks accurately graduated at 110 cubic centimeters.

Titration of the volatile acid.—The 110 cubic centimeters of distillate, after thorough mixing, are filtered through perfectly dry filter paper and collected in a flask graduated

at 100 cubic centimeters. The 100 cubic centimeters of the filtered distillate are poured into a beaker holding from 200 to 250 cubic centimeters, 0.5 centimeters phenolphthalein solution added, and decinormal barium hydrate run in until a red color is produced. The contents of the beaker are then returned to the measuring flask to remove any acid remaining therein, poured again into the beaker, and the titration continued until the red color produced remains apparently unchanged for two or three minutes.

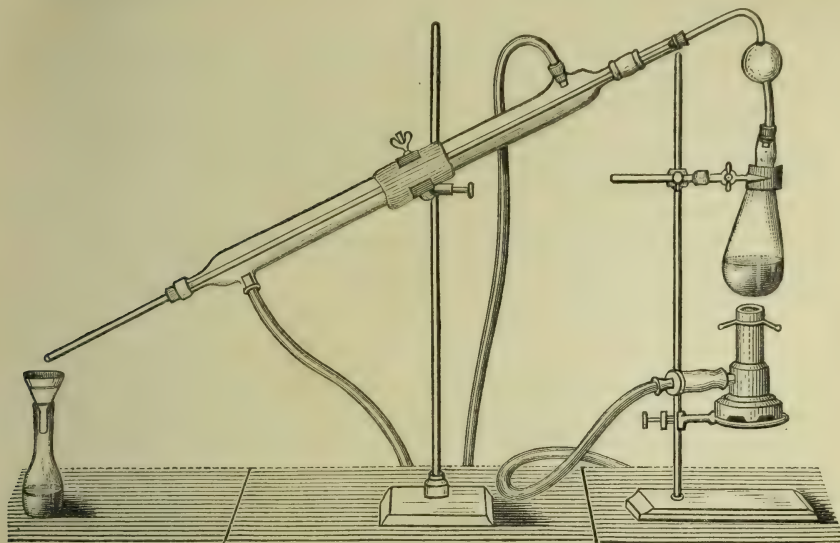


FIG. 19.

ALTERNATE METHOD OF DETERMINING VOLATILE ACIDS.

SAPONIFICATION WITHOUT THE USE OF ALCOHOL.

To avoid the danger of loss from the formation of ethers and the trouble of removing the alcohol after saponification the fat may be saponified with a solution of caustic potash in a closed flask without alcohol. The operation is carried on exactly as indicated above for saponification in a closed flask, using caustic potash solution instead of soda, and omitting the operation for volatilizing the alcohol. The caustic potash is prepared as follows: Dissolve 100 grams of the purest potassium hydrate in 58 grams of hot distilled water. Allow to cool in a stoppered vessel, decant the clear caustic solution, and preserve in a vessel out of contact with the air. For the saponification use 2 cubic centimeters of the caustic potash solution, which is poured on the fat after it has solidified in the flask. Great care must be taken that none of the fat is allowed to rise on the sides of the saponifying flask to a point where it can not be reached by the alkali. During the process of saponification the flask can only be very gently rotated in order to avoid the difficulty mentioned above. This process is not recommended in any except a closed flask with round bottom. In the subsequent solution of the soap use only 80 cubic centimeters of distilled water and in setting free the fatty acids use 60 cubic centimeters of the dilute sulphuric acid. In other respects the distillation is conducted as described. Potash is used instead of soda, so as to form a softer soap and thus allow a more perfect saponification.

The saponification may also be conducted as follows: The alkali and fat in the melted state are shaken vigorously in the saponification flask until a complete emulsion is secured. The rest of the operation is then conducted as above.

IODINE EQUIVALENT.

REAGENTS.

1. Dissolve 25 grams of pure iodine in 500 cubic centimeters of 95 per cent alcohol. Dissolve 30 grams of mercuric chloride in 500 cubic centimeters of 95 per cent alcohol. The last solution, if necessary, is filtered and then the two solutions mixed. The mixed solution should be allowed to stand twelve hours before using.

2. *Decinormal hyposulphite of sodium solution.*—Take 24.6 grams of chemically pure hyposulphite of soda freshly pulverized as finely as possible and dried between filter or blotting paper. Make this up to 1,000 cubic centimeters at the temperature at which the titrations are to be made.

3. *Starch paste.*—One gram of starch boiled in 200 cubic centimeters of distilled water for ten minutes and cooled to room temperature.

4. *Solution of iodide of potassium.*—150 grams of iodide of potassium dissolved in water and made up to 1 liter.

5. *Solution of bichromate of potassium.*—Dissolve 3.874 grams chemically pure bichromate of potassium in distilled water and make the volume up to 1 liter at the temperature at which the titrations are to be made.

MANIPULATION.

Standardizing the hyposulphite of sodium solution.—Run 20 cubic centimeters of the bichromate of potassium solution into a glass stoppered flask to which has been added 10 cubic centimeters of the solution of iodide of potassium. Add to this 5 cubic centimeters of strong hydrochloric acid. Allow the solution of hyposulphite of sodium to flow slowly into the flask until the yellow color of the liquid has almost disappeared. Add a few drops of the starch paste and with constant shaking continue to add the hyposulphite of sodium solution until the blue color just disappears. The number of cubic centimeters of hyposulphite solution used multiplied by 5 is equivalent to 1 gram of iodine.

Example.—20 cubic centimeters $K_2Cr_2O_7$ solution required 16.2 cubic centimeters hyposulphite of soda; then $16.2 \times 5 = 81 =$ number cubic centimeters of hyposulphite solution equivalent to 1 gram of iodine. Then 1 cubic centimeter hyposulphite solution $= 0.0124$ gram of iodine. Theory for decinormal solution of hyposulphite of sodium, 1 cubic centimeter $= 0.0127$ gram of iodine.

Weighing the sample.—About 1 gram of butter fat is to be weighed in a glass-stoppered flask holding about 300 cubic centimeters with the precautions mentioned for weighing the fat for determining volatile acids.

Absorption of iodine.—The fat in the flask is dissolved in 10 cubic centimeters of chloroform. After complete solution has taken place 30 cubic centimeters of the iodine-mercuric chloride solution are added. The flask is now placed in a dark place and allowed to stand with occasional shaking for three hours.

Titration of the unabsorbed iodine.—100 cubic centimeters of distilled water are added to the contents of the flask, together with 20 cubic centimeters of the iodide of potassium solution. Any iodine which may be noticed upon the stopper of the flask should be washed back into the flask with the iodide of potassium solution. The excess of iodine is now oxidized with the hyposulphite of sodium solution, which is run in gradually with constant shaking until the yellow color of the solution has almost disappeared. A few drops of starch paste are then added and the titration continued until the blue color has entirely disappeared. Toward the end of the reaction the flask should be stoppered and violently shaken so that any iodine remaining in solution in the chloroform may be taken up by the iodide of potassium solution in the water. A sufficient quantity of hyposulphite of sodium solution should be added to prevent a reappearance of any blue color in the flask for five minutes.

Setting the value of the iodine solution by the hyposulphite solution.—At the time of

adding the iodine solution to the fats two blank flasks of the same size and nature as those used for the determination should be employed for conducting the operation described above without the presence of any fat. In every other respect the conduct of the blank experiments should be just as described. These blank experiments must be made each time the iodine solution is used.

EXAMPLE.

BLANK DETERMINATIONS.

(1) 30 cubic centimeters iodine solution requires 46.4 cubic centimeters hyposulphite of sodium solution.

(2) 30 cubic centimeters iodine solution requires 46.8 cubic centimeters of hyposulphite of sodium solution.

Mean 46.6.

PERCENTAGE OF IODINE ABSORBED.

Weight of fat taken	grams..	1.0479
Quantity of iodine solution used	cubic centimeters..	30
Hypsulphite equivalent of iodine used	do.....	46.6
Hypsulphite to oxidize remaining iodine.....	do.....	14.7
Hypsulphite equivalent to iodine absorbed.....	do.....	31.9
Percentage of iodine absorbed, $31.9 \times 0.0124 \times 100 \div 1.0479 = 37.75$ per cent.		

ELECTIVE DETERMINATIONS.

For the further study of the properties of butter the following recommendations are made, to be followed by the analyst or not as he may elect:

Reduction of silver.—To determine whether or not the butter has been derived from a cow fed on cotton-seed meal it will usually be sufficient to test the sample by Bechi's reagent.

The solutions used are as follows: Five grams of silver nitrate dissolved in 100 cubic centimeters, 95 per cent alcohol, and 1 cubic centimeter of strong nitric acid added. The manipulation is conducted as follows: Measure out 5 cubic centimeters of the fat into a small porcelain dish and add 5 cubic centimeters of the above reagent. Stir together thoroughly with a stirring rod and place upon the steam bath for ten minutes. Notice the changes of color which take place, the intensity of the color produced, and the amount of silver deposited as a mirror on the sides of the dish.

Reduction test applied to the fatty acids.—Instead of testing the original glycerides as above the test may be applied to the fatty acids in accordance with the following directions:

Reagent.—Dissolve 30 grams of nitrate of silver in 100 cubic centimeters of water.

Manipulation.—Place 5 cubic centimeters of the fatty acid in the porcelain dish which is used above and dissolve in 20 cubic centimeters of 95 per cent alcohol. Add 2 cubic centimeters of the reagent, stir thoroughly together, and heat on the water bath as in the first instance.

Melting point of the fatty acids.—The melting point of the fatty acids may be determined as described in Part 4, Bulletin No. 13, page 448.

The melting point of the fatty acids can not be determined in the same apparatus and by the same methods as those described for the fats themselves, because the acids are soluble in alcohol. It should be remembered that the melting point of the fatty acids is slightly above that of the glycerides, and the first determination in every case should be solely for the purpose of determining approximately the temperature at which the fat melts.

The bulb of a delicate thermometer is coated with the fatty acid, and the thermom-

eter by means of a cork is fastened in a round flask of 250 cubic centimeters capacity. The bulb of the instrument should occupy as nearly as possible the center of the flask. The cork should have an air passage for the equalization of the pressure. The flask is slowly heated in a current of warm air, or otherwise, and as the melting point is approached a rotary motion is given to it. When the fat melts it is seen to collect in a small drop on the lowest part of the bulb, remaining stationary while the flask is turned. The thermometer is best held horizontally.

Crystallizing point of the fatty acids.—The crystallizing point of the fatty acid is determined by means of the method described in Bulletin No. 13, Part 4, page 447.

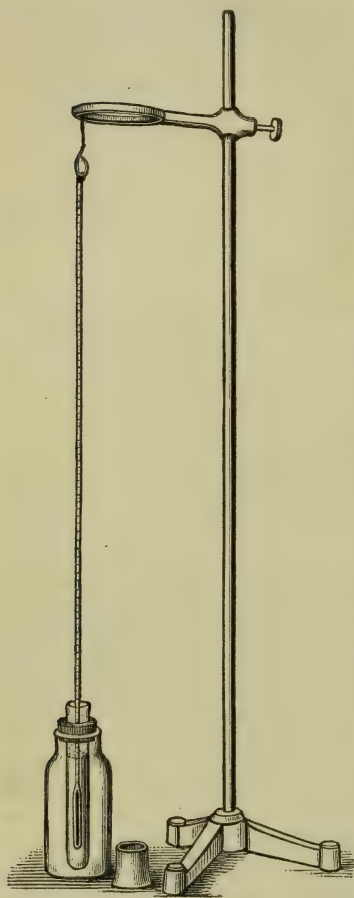


FIG. 20.

A very delicate thermometer with a long bulb is used, the thermometer being graduated to tenths of a degree; the readings of the mercury are made with a small eyeglass. A test tube about 15 centimeters in length and 2.5 to 3 centimeters in diameter is filled with the melted fatty acids. The temperature at which the acid is melted should be sufficiently high to secure a complete liquefaction. The tube containing the fat is placed in a stopper carried in a bottle so that the whole of the fatty acid may be contained in that part of the tube protected from external currents of air by the bottle. The bottom of this protected bottle should be warm so that its temperature may be several degrees higher than the crystallizing point of the fatty acid. This precaution is necessary to avoid a too rapid crystallization of the fatty acid in the bottom of the test tube, and to secure as nearly as possible a uniform crystallization throughout the whole mass. The thermometer is suspended in such a manner that the bulb may occupy as nearly as possible the center of the fatty mass. The thermometer should be protected from currents of air and should be kept perfectly still. The position of the mercury in the thermometer is carefully watched by the attendant as it gradually sinks toward the crystallizing point. When the crystals of the acid begin to appear in the bottom and on the sides of the test tube the descent of the mercury will become very slow and finally cease. The lowest point reached by the mercury should be noted. As the crystallization extends inward toward the bulb of the thermometer a point will be reached when the mercury will begin to rise. At that

point, the test tube being held by the left hand, the thermometer should be taken by the right hand of the operator, and the partially crystallized mass of fat thoroughly stirred by turning the thermometer three or four times around the tube in both directions. Care should be exercised that at the end of this operation the bulb of the thermometer should hang as near as possible in the center of the crystallizing mass. Directly the above operation is accomplished the mercury will be seen to rise, and this rise of temperature will continue for some time, after which the mercury will remain stationary for one or two minutes. The highest point reached is taken as the true temperature of crystallization.

Refractive index.—The refractive index is conveniently determined by the apparatus of Professor Abbe, Fig. 21. The manipulation is conducted as follows: Fine tissue

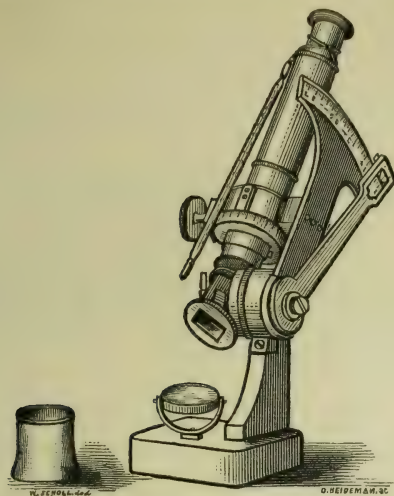


FIG. 21.

paper or rather heavy body is cut into rectangular pieces 3 centimeters in length by 1.5 centimeters in breadth. One of these pieces of paper is placed on the lower of the two glass prisms of the apparatus. Two or three drops of the oil or fat are placed upon the paper and the upper prism carefully placed in position so as not to move the paper from its place. In charging the apparatus with the oil in this way, it is placed in the horizontal position. After the paper disk holding the fat is secured by replacing the upper prism, the apparatus is placed in its normal position and the index moved until the light directed through the apparatus by the mirror shows the field of vision divided into dark and light portions. The dispersion apparatus is now turned until the rainbow colors on the part between the dark and light field have disappeared. Before doing this, however, the telescope, the eyepiece of the apparatus, is so adjusted as to bring the cross lines of the field of vision distinctly into focus. The index of the apparatus is now moved back and forth until the dark edge of the field of vision falls exactly in the intersection of the cross lines. The refractive index of the fat under examination is then read directly upon the scale by means of a small magnifying glass. To check the accuracy of the first reading, the dispersion apparatus should be turned through an angle of 180° until the colors have again disappeared and the scale of the instrument again read. Those two readings should fall closely together, and their mean is the true reading of the fat under examination.

For butter fats the apparatus should be kept in a warm place, the temperature of which does not fall below 30°C . For reducing the results obtained to a standard temperature, say 25°C , the following factor may be used. The mean rate of variation in the refractive index of butter fats for each degree of temperature was determined by me in twelve samples of butter fat (see *Journal of Analytical Chemistry*, Vol. 2, Part 3, July, 1888). This factor is .000176. As the temperature rises the refractive index falls.

Example.

Refractive index of a butter fat determined at $32^\circ 4' = 1.4540$, reduced to 25°C , as follows: $32.4 - 25 = 7.4 = 0.0013$; then $1.4540 + 0.0013 = 1.4553$.

The instrument used should be set with distilled water at 25°C , the theoretical refractive index of water at that temperature being 1.3330. In the determination above

given the refractive index of pure water measured 1.3300; hence the above numbers should be corrected for theory by the addition of 0.0030, making the corrected index of the butter fat mentioned at the temperature given, 1.4583.

Soluble and insoluble acids.—Use method described in Bulletin 13, Part 4, pages 455 to 461.

Saponification equivalent.—Use method described in Bulletin 13, Part 4, pages 461, 462.

Rise of temperature with sulphuric acid.—Use method described in Bulletin 13, Part 4, pages 443–446.

METHODS FOR MILK ANALYSIS.

WATER.

Evaporate 1 to 2 grams of milk in a tared flat dish containing from 15 to 20 grams of pure dry sand, or without sand, until apparently dry. Transfer to air bath and dry for one hour at temperature of boiling water. Cool in desiccator and weigh rapidly to avoid absorption of hygroscopic moisture.

TOTAL NITROGENOUS MATTER.

Place in a Kjeldahl digestion flask a known weight (about 5 grams) of milk and proceed exactly as described for this method by the nitrogen reporter.

FAT; METHOD OF ADAMS, MODIFIED BY WILEY.

Coils made of thick filter paper, cut into strips 2.5 by 25 inches, are thoroughly extracted with ether and alcohol or the weight of the extract corrected by a constant obtained for the paper. About 5 cubic centimeters of the well mixed milk are placed in a small beaker, covered with a watch glass, and weighed. From a weighing bottle about 5 grams of milk are transferred to the coil by a pipette, care being taken to keep the end of the coil held in the fingers dry. The coil, dry end down, on a piece of glass is dried at the temperature of boiling water for one hour, or better dried in hydrogen at temperature of boiling water, transferred to a syphon extraction apparatus and extracted by at least 12 syphonings with absolute ether or petroleum spirit boiling at about 45° C. The extracted fat is dried in hydrogen and weighed.

ALTERNATE METHOD OF ESTIMATING WATER AND FAT IN MILK.

Method of Babcock.—In the bottom of a perforated test-tube is placed a clump of clean cotton, the tube is then filled three-quarters full of ignited asbestos, lightly packed, and a plug of cotton inserted over it. The tube and contents are weighed and the plug of cotton carefully removed and 5 grams of milk from a weighed pipette run into it, and the plug of cotton replaced. The tube connected at its lower end by a rubber tube and adapter with a filter pump is placed in a drying oven at a temperature of 100° C., and a slow current of dry air drawn through it until the water is completely expelled, which in no case requires more than two hours.

The tube containing the solids from the above operation is placed in an extraction apparatus and exhausted with ether in the usual way.

THE ESTIMATION OF SUGAR.

The reagents, apparatus, and manipulation necessary to give the most reliable results in milk-sugar estimation are as follows:

Reagents.—(1) *Basic plumbic acetate*, specific gravity 1.97. Boil a saturated solution of sugar of lead with an excess of litharge, and make it of the strength indicated above. One cubic centimeter of this will precipitate the albumens in 50 to 60 cubic centimeters of milk.

(2) *Acid mercuric nitrate*. Dissolve mercury in double its weight of nitric acid, specific gravity 1.42. Add to the solution an equal volume of water. One cubic centimeter of this reagent is sufficient for the quantity of milk mentioned above. Larger quantities can be used without affecting the results of polarization.

(3) *Mercuric iodide with acetic acid*. KI 33.2 grams, HgCl_2 13.5 grams, $\text{C}_2\text{H}_4\text{O}_2$ 20 cubic centimeters, H_2O 64 cubic centimeters.

Apparatus.—(1) Pipettes marked at 59.5, 60, and 60.5 cubic centimeters. (2) Sugar flasks marked at 102.4 cubic centimeters. (3) Filters, observation tubes, and polariscope. (4) Specific gravity spindle and cylinder. (5) Thermometers.

Manipulation.—(1) The room and milk should be kept at a constant temperature. It is not important that the temperature should be of any given degree. The work can be carried on equally well at 15°C ., 20°C ., or 25°C . The slight variations in rotary power within the above limits will not affect the result for analytical purposes. The temperature selected should be the one which is most easily kept constant.

(2) The specific gravity of the milk is determined. For general work this is done by a delicate specific gravity spindle. Where greater accuracy is required use specific gravity flask.

(3) If the specific gravity be 1.026, or nearly so, measure out 60.5 cubic centimeters into the sugar flask. Add one cubic centimeter of mercuric nitrate solution, or 30 cubic centimeters mercuric iodide solution, and fill to 102.4 cubic centimeter mark. The precipitated albumen occupies a volume of about 2.44 cubic centimeters. Hence the milk solution is really 100 cubic centimeters. If the specific gravity is 1.030, use 60 cubic centimeters of milk. If specific gravity is 1.034, use 59.5 cubic centimeters of milk.

(4) Fill up to mark in 102.4 cubic centimeter flask, shake well, filter, and polarize.

NOTES.—In the above method of analysis the specific rotatory power of milk sugar is taken at 52.5, and the weight of it in 100 cubic centimeter solution to read 100 degrees in the cane-sugar scale at 20.56 grams. This is for instruments requiring 16.19 grams, sucrose to produce a rotation of 100 sugar degrees. It will be easy to calculate the number for milk-sugar, whatever instrument is employed.

Since the quantity of milk taken is three times 20.56 grams, the polariscopic readings divided by 3 give at once the percentage of milk sugar when a 200-millimeter tube is used.

If a 400-millimeter tube is employed, divide reading by 6; if a 500-millimeter tube is used, divide by 7.5.

Since it requires but little more time, it is advisable to make the analysis in duplicate and take four readings for each tube. By following this method gross errors of observation are detected and avoided.

By using a flask graduated at 102.4 for 60 cubic centimeters no correction for volume of precipitated casein need be made. In no case is it necessary to heat the sample before polarizing.

ALTERNATE METHOD.

The sugar may also be determined either gravimetrically or volumetrically by alkaline copper solution.

ESTIMATION OF ASH.

Evaporate to dryness in a weighed platinum dish 20 cubic centimeters of milk from a weighing bottle, to which 6 cubic centimeters of HNO_3 has been added, and burn at low red heat until ash is free from carbon.

METHODS OF DETERMINING POTASH.

METHOD OF LINDO AS MODIFIED BY GLADDING.

(1) *Superphosphates*.—Pulverize the fertilizer (200 or 300 grams) in a mortar. Boil 10 grams with 300 cubic centimeters of water for thirty minutes; add ammonia in

slight excess and then a little oxalate of ammonia, thus precipitating all phosphate and sulphate of lime, oxide of iron, and alumina, etc.; make up to 500 cubic centimeters, mix thoroughly, and filter through a dry filter; take 50 cubic centimeters, corresponding to 1 gram, evaporate nearly to dryness, add 1 cubic centimeter of dilute H_2SO_4 (1 to 1), and evaporate to dryness and ignite to whiteness. As all the potash is in form of sulphate, no loss need be apprehended by volatilization of potash, and a full red heat must be used until the residue is perfectly white. This residue is dissolved in hot water plus a few drops of HCl , 5 cubic centimeters of a solution of pure NaCl (containing 20 grams NaCl to the liter), and an excess of platinum solution (4 cubic centimeters) are now added. This solution is then evaporated to dryness in a small dish, the residue taken up with a little water sufficient to dissolve it, and strong alcohol added. The precipitate is washed thoroughly with alcohol by decantation and on filter as usual. The washing should be continued even after the filtrate is colorless. Ten cubic centimeters of the NH_4Cl solution prepared as directed are now run through the filter, or the washing may be performed in the dish. This 10 cubic centimeters will contain the bulk of the impurities, and is thrown away. Fresh portions of 10 cubic centimeters NH_4Cl are now run through the filter several times (five or six). The filter is then washed thoroughly with pure alcohol, dried, and weighed as usual. The platinum solution used contains 1 gram metallic platinum in every 10 cubic centimeters.

(2) *Muriates of potash*.—In the analysis of these salts an aliquot portion, containing 0.500 gram, is evaporated with 10 cubic centimeters platinum solution plus a few drops of HCl , and washed as before.

(3) *Sulphate of potash, kainite, etc.*—In the analysis of these salts an aliquot portion containing 0.500 gram is taken, 0.250 gram of NaCl added, plus a few drops of HCl , and the whole evaporated with 15 cubic centimeters platinum solution. In this case special care must be taken in the washing with alcohol to remove all the double chloride of platinum and sodium. The washing should be continued for some time after the filtrate is colorless. Twenty-five cubic centimeters of the NH_4Cl solution are employed instead of 10 cubic centimeters, and the 25 cubic centimeters poured through at least six times to remove all sulphates and chlorides. Wash finally with alcohol, dry, and weigh as usual.

(4) *Organic compounds*.—In case the potash is contained in organic compounds like tobacco stems, cotton-seed hulls, etc., weigh out 10 grams, saturate with strong sulphuric acid, and ignite in a muffle to destroy organic matter; then proceed as under (1). To prepare the washing solution of NH_4Cl , place in a bottle 500 cubic centimeters H_2O , 100 grams of NH_4Cl ; shake till dissolved. Now pulverize 5 or 10 grams of K_2PtCl_6 , put in a bottle, and shake at intervals for six or eight hours; let settle overnight; then filter off liquid into a second bottle. The first bottle is then ready for a preparation of a fresh supply when needed.

ALTERNATE METHODS.

Prepare the fertilizer as for the Lindo-Gladding method; take 10 grams, boil for ten minutes with 200 cubic centimeters water, and after cooling, and without filtering, make up to 1,000 cubic centimeters, and filter through a dry paper. If the sample have 10 to 15 per cent K_2O (kainite), take 50 cubic centimeters of the filtrate; if from 2 to 3 per cent K_2O (ordinary potash fertilizers), take 100 cubic centimeters of the filtrate. In each case make the volume up to 150 cubic centimeters, heat to 100°C , and add, drop by drop, with constant stirring, slight excess of barium chloride; without filtering, in the same manner, add barium hydrate in slight excess. Heat, filter, and wash until precipitate is free of chlorides. Add to filtrate 1 cubic centimeter strong ammonium hydrate and then a saturated solution of ammonium carbonate, until excess of barium is precipitated. Heat. Add now, in fine powder, 0.5 gram pure oxalic acid or 0.75 gram ammonium oxalate. Filter, wash free of chlorides; evaporate filtrate to dryness in a platinum dish, and holding dish with crucible tongs, ignite carefully over the free flame below red heat until all volatile matter is driven off.

The residue is now digested with hot water, filtered through a small filter, and washed with successive small portions of water until the filtrate amounts to 30 cubic centimeters or more. To this filtrate, after adding two drops of strong hydrochloric acid, is added, in a porcelain dish, 5 to 10 cubic centimeters of a solution of 10 grams of platinic chloride in 100 cubic centimeters of water. The mixture is now evaporated on the water bath to a thick sirup, or further, as above treated with strong alcohol, washed by decantation, collected in a Gooch crucible or other form of filter, washed with strong alcohol, afterwards with 5 cubic centimeters ether, dried for thirty minutes at 100° C., and weighed.

It is desirable, if there is an appearance of foreign matter in the double salt, that it should be washed, according to the previous method, with 10 cubic centimeters of the half-concentrated solution of NH_4Cl , which has been saturated by shaking with K_2PtCl_6 , as recommended by Gladding.

The use of the factor 0.3056 for converting K_2PtCl_6 to KCl and 0.19308 for converting to K_2O are continued.

THE OFFICIAL METHOD FOR THE ANALYSIS OF NON-STARCHY FOODS (COARSE FODDERS, OIL SEEDS, AND OTHER RESIDUES) FOR 1890-'91.

PREPARATION OF THE SAMPLE.

The substance is to be ground till all of it will pass through a sieve with circular holes 1 millimeter in diameter.

HYGROSCOPIC WATER.

Dry 2 to 3 grams of the substance for four hours, heated fully to the temperature of boiling water, in a current of dry hydrogen, but without allowing the glass containing it to come in contact with the boiling water.

ASH.

Char the substance at a low red heat, which is conveniently done in a Fletcher gas muffle furnace, heated not by the large gas burner that is supplied with the furnace, but by a Fletcher solid flame burner (No. 46b.); exhaust this charred mass with water; collect the insoluble residue on a filter, burn, add this ash to the residue from the evaporation of the above aqueous extract and heat the whole to low redness till the ash is white.

ETHER EXTRACT.

Extract 2 to 3 grams of the substance dried as for the determination of the moisture, with anhydrous and alcohol-free ether, sixteen hours. Dry the extract by exposure to the full heat of boiling water, in a current of dry hydrogen, to constant weight.

CRUDE PROTEIN.

Determine nitrogen by the Kjeldahl method as directed for nitrogen in fertilizers, and multiply the result by 6.25 for the crude protein.

ALBUMINOID NITROGEN.

Stutzer's method.—Prepare cupric hydrate as follows: Dissolve 100 grams of pure cupric sulphate in 5 liters of water, and add 2.5 cubic centimeters of glycerine; add dilute solution of sodium hydrate until the liquid is alkaline; filter; rub the precipitate up with water containing 5 cubic centimeters of glycerine per liter, and then wash by decantation or filtration until the washings are no longer alkaline. Rub

the precipitate up again in a mortar with water containing 10 per cent of glycerine, thus preparing a uniform gelatinous mass that can be measured out with a pipette. Determine the quantity of cupric hydrate per cubic centimeter of this mixture. To 1 gram of this substance add 100 cubic centimeters of water in a beaker, heat to boiling, or in the case of substances rich in starch heat on the water bath ten minutes, add a quantity of cupric hydrate mixture containing 0.7 to 0.8 grams of the hydrate, stir thoroughly, filter when cold, wash with cold water, and put the filter and its contents into the concentrated sulphuric acid for the determination of nitrogen after Kjeldahl. For the above filtration use Schleicher and Schüll's No. 559 paper, or Swedish paper, either of which contains so little nitrogen that it can be left out of account.

If the substance examined consists of seed of any kind, or residues of seeds, such as oil cake or anything else rich in alkaline phosphate, add a few cubic centimeters of a concentrated solution of alum just before adding the cupric hydrate, and mix well by stirring. This serves to decompose the alkaline phosphate. If this is not done cupric phosphate and free alkali may be formed and the protein copper may be partially dissolved in the alkaline liquid.

CRUDE FIBER.

Extract 2 grams of the substance with ordinary ether, at least nearly completely; or take the residue from the determination of the ether extract. To this residue, in a 500 cubic centimeter (Erlenmeyer) flask, add 200 cubic centimeters of boiling 1.25 per cent sulphuric acid; connect the flask with a return-flow condenser, the tube of which passes only a short distance beyond the rubber stopper into the flask. Boil at once, and continue the boiling for thirty minutes. A blast of air conducted into the flask may serve to reduce the frothing of the liquid.

Filter; wash thoroughly with boiling water till the washings are no longer acid; rinse the substance back into the same flask with 200 cubic centimeters of a boiling 1.25 per cent solution of sodium hydrate at least almost free from sodium carbonate; boil at once, and continue the boiling for thirty minutes in the same manner as directed above for the treatment with acid. Filter in a Gooch crucible and wash with boiling water till the washings are neutral; dry at 110° C.; weigh; incinerate completely, and give the loss of weight for crude fiber.

The filter used for the first filtration may be linen, one of the forms of glass wool, and asbestos filters recommended in the last report, or any other form that secures clear and reasonably rapid filtration. The carbonate free sodium hydrate can be obtained of the Troy Laundry Machinery Company, 32 Dey street, New York, or 297 Wabash avenue, Chicago, under the name of "Greenbank Alkali Company," double refined 98 per cent caustic soda, it being the same as that recommended for the Kjeldahl nitrogen method. The solutions of sulphuric acid and sodium hydrate are to be made up of the specified strength accurately by titration, and not merely by the areometer.

METHODS OF SUGAR ANALYSIS.

By the term "sugar analysis" it is understood that the analyses of all the common saccharine substances, viz, sugar, molasses, sirup, starch, sugar, and honey are embraced. In the following directions an attempt will be made to indicate the general principles which should guide the practice of sugar analysis, together with sufficient detail to enable these analyses to be carried out with accuracy and uniformity.

The principal components to be determined in the substances mentioned above are:

- | | |
|------------------------|------------------|
| 1. Water. | 5. Sucrose. |
| 2. Ash. | 6. Lactose. |
| 3. Nitrogenous bodies. | 7. Starch sugar. |
| 4. Reducing sugar. | 8. Raffinose. |

WATER.

In sugar or melada.—Weigh from 2 to 5 grams into a flat dish (nickel or platinum) and dry at temperature of boiling water for three hours; cool in desiccator and weigh; return to oven and dry for one hour. If on weighing there is only a slight change of weight, the process may be considered finished; otherwise the drying must be continued until the loss of water in one hour is not greater than 0.20 per cent.

In honey or molasses.—(a) Proceed as above, using only 1 to 2 grams of substance.

(b) Place 2 to 3 grams of substance in a flat dish holding from 30 to 50 cubic centimeters; dissolve in 70 per cent alcohol, using a small stirring rod, which is weighed with the dish. Add from weighing bottle 15 to 25 grams pure dry sand; dry in oven at 70° to 80° C. until alcohol is nearly driven off; moisten thoroughly with 99 per cent to absolute alcohol; dry at 75° C. for thirty minutes, then at temperature of boiling water for an hour; repeat as above, deduct weight of added sand, and make usual calculations.

ASH.

(a) Take 5 to 10 grams of the material (sugar, molasses, honey) in platinum dish* of 50 to 100 cubic centimeters capacity; heat at 100° C. until water is expelled and then slowly until intumescence ceases. The dish is then placed in muffle and heated at low redness until a white ash is obtained.

(b) *Soluble ash.*—Digest ash with water, filter onto Gooch crucible, wash with hot water, dry residue at 100° C., and weigh. Difference of weights equals soluble ash.

(c) Use 50 mg. zinc oxide to 25 grams molasses or 50 grams sugar. Incorporate thoroughly by adding dilute alcohol and mixing; dry and ignite as above. Deduct weight of zinc used from weight of ash.

(d) Carbonize the mass at a low heat; dissolve soluble salts with hot water; burn residual mass as above, add the solution of soluble salts, and evaporate to dryness at 100° C.; ignite gently, cool in desiccator, and weigh.

(e) Saturate sample with H_2SO_4 , dry, ignite gently, then burn in muffle at low redness.

(f) Dissolve 10 grams of sugar in hot water and filter to remove sand, etc.; evaporate filtrate and washings to dryness; carefully carbonize and extract with hot water until there is no longer any reaction for chlorine. Dry and ignite residue; weigh as insoluble ash. Add the soluble portion, treat with HCl in slight excess, and evaporate to dryness. Heat until all free HCl is driven off; take up with H_2O and a little HCl , filter and wash. The residue is silica. Add NH_4OH to filtrate, boil and filter, wash residue, which is iron and alumina. To filtrate add $(\text{NH}_4)_2\text{C}_2\text{O}_4$, evaporate to dryness; ignite and moisten with $(\text{NH}_4)_2\text{CO}_3$ and reignite; dissolve in water, filter, and wash. Residue equals carbonates of Ca and Mg . Evaporate filtrate to small bulk, add $(\text{NH}_4)_2\text{CO}_3$, and evaporate to dryness; drive off excess of ammonia cautiously and weigh. This gives the alkalis as carbonates, and this weight added to the insoluble ash, formerly determined, gives the total carbonate ash.

NITROGENOUS BODIES.

Any of the methods adopted by the association for the estimation of nitrogen may be used.

REDUCING SUGAR.

Reagent, alkaline copper solution. (Fehling, Violette.)

34.64 grams pure crystallized copper sulphate.

187.00 grams tartrate soda and potash.

78.00 grams caustic soda.

* If the substance contains tin or other metal capable of uniting with platinum a dish made of some other material must be used.

Dissolve the $\text{CuSO}_4 + 5\text{H}_2\text{O}$ and make up to 1,000 cubic centimeters at the average temperature at which the analyses are made. Mix the solutions of Rochelle salts and caustic soda and make up to 1,000 cubic centimeters. In practice use equal volumes of each reagent.

Processes (volumetric).—(a) The solution to be examined should contain about 1 per cent of reducing sugar. To 10 cubic centimeters of the copper solution and 10 cubic centimeters of the alkali, in a large test tube, add 20 cubic centimeters of water and boil. Add the sugar solution in approximately the proper quantity to reduce the copper, and boil for exactly two minutes. If, on standing for a moment, the solution is still blue, add more sugar solution and reboil. When no longer able to distinguish any residual copper by the eye, suck a few drops of the boiling hot liquid into an end reaction tube and test the filtrate for Cu with ferro-cyanide of potassium solution and acetic acid. If copper be still present, add the sugar solution little by little, boil, and retest until no copper is found. Having thus determined the approximate quantity of sugar solution to be used, repeat the test twice, adding at first each time almost the entire quantity of sugar solution necessary to complete reduction.

(b) *Gravimetric.*—Take 25 cubic centimeters of copper solution of following composition:

34.639 grams $\text{CuSO}_4 + 5\text{H}_2\text{O}$ in 500 cubic centimeters of water, add in Erlenmeyer flask 25 cubic centimeters of alkali solution made as follows:

173 grams Rochelle salts } in 500 cubic centimeters water.
51.6 grams NaOH

Add 50 cubic centimeters of a sugar solution of such strength as to leave a part of the copper unreduced; heat quickly to boiling point and boil for exactly two minutes; add 100 cubic centimeters recently boiled, cold, distilled water. The liquid is poured at once into a filter tube made of hard glass with asbestos diaphragm (an ordinary extraction tube is well adapted for this purpose). The asbestos film should be previously moistened. Bring finally all the separated suboxide into the tube with the help of a feather brush, and wash with 300 to 400 cubic centimeters of boiling water; afterward with 20 cubic centimeters absolute alcohol, and finally with ether; then dry, heat to low redness to convert into oxide and to destroy any organic matter. The copper may also be weighed in the metallic state after reduction in a stream of dry hydrogen. The tube should in all cases be kept in a desiccator before weighing.

(c) (*Gravimetric.*)

Reagents:

34.639 grams $\text{CuSO}_4 + 5\text{H}_2\text{O}$ }
125.000 grams NaOH } in 500 cubic centimeters.
173.000 grams Rochelle salts }

Process.—In a beaker of 250 cubic centimeters capacity place 25 cubic centimeters each of the reagents and 50 cubic centimeters of water. Heat to boiling and add 25 cubic centimeters of the solution to be tested, which should contain about 1 per cent of reducing sugar (dextrose, levulose). Boil for exactly two minutes, decant into a Gooch crucible, wash by decantation with 100 cubic centimeters of boiling-hot water, keeping the cuprous oxide in the beaker constantly covered. Place the beaker containing the cuprous oxide in place of the one receiving the wash water and dissolve the Cu_2O in a Gooch crucible in a fine stream of HNO_3 ; wash until all $\text{Cu}(\text{NO}_3)_2$ is removed. Transfer the whole of the nitrate from the beaker to a tared platinum dish, add a little H_2SO_4 , and evaporate over steam bath until all HNO_3 is expelled and the Cu is converted into CuSO_4 ; connect with battery of four gravity cells and allow electrolytic action to continue for three hours or until all the Cu is deposited. (Connect the dish with the zinc pole of the battery.) Pour off the acid solution, adding water until all trace of H_2SO_4 is removed; wash with 95 per cent alcohol and finally with absolute alcohol; ignite residual alcohol, cool in desiccator, and weigh; calculate sugar reduced from weight of metallic copper by the following factors:

(1) Multiply weight of copper by 0.5698 for weight of invert sugar.

(2) Multiply weight of copper by 0.5808 for weight of anhydrous dextrose.

These factors are correct only for a copper solution of above strength and reducing sugar of approximately 1 per cent strength.

Sucrose.—(Optical method, to be used when the sugar is approximately pure.)

(a) Dissolve 26.048 (for the Ventzke), (16.19 for the Laurent scale) grams of sugar in water at temperature at which the polarization is to be made, and, after clarification, make the volume up to 100 cubic centimeters. The sugar is conveniently weighed in a counterpoised nickel or German silver dish with large lip, whence it is readily washed into the flask. The solution before being filled to the mark is clarified by the addition of lead subacetate or phospho-tungstic acid until no further precipitation takes place. Excess of lead should be avoided. The filtration and clarification may often be helped by adding a few drops of suspended aluminic hydrate after the lead.

The flask is filled with pure water until the lower line of the meniscus coincides with the mark on the neck. The mouth of the flask is closed with the thumb and its contents well shaken, and poured into a folded filter; the first 15 to 20 cubic centimeters of the filtrate are rejected. The subsequent filtrate, if not perfectly clear, is returned to the filter, and this continued until the filtrate shows no cloudiness. A 200 (100 to 500) millimeter tube is filled with the solution, placed in the polariscope, the scale of which, after neutralizing the rotation produced by the sugar by turning the analytical prism or moving the quartz wedge, will give the percentage of sucrose in the sample taken. A dark solution may either be read in a 100-millimeter tube or the solution may be decolorized by shaking it with a small quantity of dry bone-black. A weak solution may be read in a tube from 300 to 500 millimeters in length.

(b) *Optical method by inversion*.—For raw sugars, molasses, etc.

(1) *Method of Clerget*.—Make up the solution as above and place 50 cubic centimeters of the filtrate in a flask marked at 50 and 55 cubic centimeters. Fill to upper mark with strong HCl and mix well; place in hot water and heat quickly to 68° C.; keep at this temperature for exactly ten minutes; remove, cool quickly to room temperature, and polarize, noting temperature. If the sample contained originally any invert sugar the second polarization should be made at approximately the same temperature as the first. The percentage of sucrose is then calculated by the following formula:

S = percentage of sucrose.

a = first polarization.

b = second polarization (usually to the left).

$a + b$ = sum of the polarizations.

t = temperature of observation in degrees C.

$$\text{then } S = \frac{a + b}{144 - \frac{t}{2}}$$

When b is to the left, a and b are to be added; when b is to the right, it is to be subtracted from a .

(2) *Method of Lindet*.—Place 50 cubic centimeters of the filtrate as above in a flask marked at 100.5 cubic centimeters; add 5 grams of powdered zinc (zinc dust), place in boiling water, and when at boiling point add, little by little, 5 cubic centimeters of strongest HCl. After the acid has all been added, cool and make up to mark. Polarize in a 400-millimeter tube, or multiply the reading in a 200-millimeter tube by 2. Calculate percentage of sucrose as before.

Gravimetric method.—Determine first any reducing sugar in sample by methods mentioned above; then invert sucrose, neutralize free acid, and redetermine the reducing sugar. Deduct the percentage of reducing sugar obtained at first, and the remainder will be reducing sugar derived from sucrose; multiply this number by 95 to obtain percentage of sucrose in sample.

LACTOSE (ANHYDROUS).

Take 20.56 grams (16.19 sucrose) or 32.99 grams (26.048 sucrose) dissolve, clarify if necessary, and complete volume to 100 cubic centimeters. The reading of the vernier scale of the instrument will give the true percentage of lactose. The lactose may also be determined by the alkaline copper method, 10 cubic centimeters standard Fehling solution is equal to .067 grams lactose. The weight of copper reduced multiplied by .7635 = lactose.

LACTOSE IN MILK.

The reagents, apparatus, and manipulation necessary to give the most reliable results in milk-sugar estimation are as follows:

Reagents.—(1) *Basic plumbic acetate*, specific gravity 1.97. Boil a saturated solution of sugar of lead with an excess of litharge, and make it of the strength indicated above. One cubic centimeter of this will precipitate the albumens in 50 to 60 cubic centimeters of milk.

(2) *Acid mercuric nitrate*. Dissolve mercury in double its weight of nitric acid, specific gravity 1.42. Add to the solution an equal volume of water. One cubic centimeter of this reagent is sufficient for the quantity of milk mentioned above. Larger quantities can be used without affecting the results of polarization.

(3) *Mercuric iodide with acetic acid*. KI 33.2 grams, HgCl_2 13.5 grams, $\text{C}_2\text{H}_4\text{O}_2$ 20 cubic centimeters, H_2O 64 cubic centimeters.

Apparatus.—(1) Pipettes marked at 59.5, 60, and 60.5 cubic centimeters. (2) Sugar flasks marked at 102.4 cubic centimeters. (3) Filters, observation tubes, and polariscope. (4) Specific gravity spindle and cylinder. (5) Thermometers.

Manipulation.—(1) The room and milk should be kept at a constant temperature. It is not important that the temperature should be of any given degree. The work can be carried on equally well at 15° C., 20° C., or 25° C. The slight variations in rotary power within the above limits will not affect the result for analytical purposes. The temperature selected should be the one which is most easily kept constant.

(2) The specific gravity of the milk is determined. For general work this is done by a delicate specific gravity spindle. Where greater accuracy is required, use specific gravity flask.

(3) If the specific gravity be 1.026, or nearly so, measure out 60.5 cubic centimeters into the sugar flask. Add 1 cubic centimeter of mercuric nitrate solution, or 30 cubic centimeters mercuric iodide solution, and fill to 102.4 cubic centimeter mark. The precipitated albumen occupies a volume of about 2.44 cubic centimeters. Hence the milk solution is really 100 cubic centimeters. If the specific gravity is 1.030, use 60 cubic centimeters of milk. If specific gravity is 1.034, use 59.5 cubic centimeters of milk.

(4) Fill up to mark in 102.4 cubic centimeter flask, shake well, filter, and polarize.

NOTES.—In the above method of analysis the specific rotatory power of milk-sugar is taken at 52.5, and the weight of it in 100 cubic centimeter solution to read 100° in the cane sugar scale at 20.51 grams. This is for instruments requiring 16.19 grams sucrose to produce a rotation of 100 sugar degrees. It will be easy to calculate the number for milk-sugar, whatever instrument is employed.

Since the quantity of milk taken is 3 times 20.51 grams, the polariscopic readings divided by 3 give at once the percentage of milk-sugar when a 200-millimeter tube is used.

If a 400-millimeter tube is employed, divide reading by 6; if a 500-millimeter tube is used, divide by 7.5.

Since it requires but little more time, it is advisable to make the analysis in duplicate and take four readings for each tube. By following this method gross errors of observation are detected and avoided.

By using a flask graduated at 102.4 for 60 cubic centimeters no correction for volume of precipitated casein need be made. In no case is it necessary to heat the sample before polarizing.

1.

PLAN A.—DIRECTIONS FOR THE EXAMINATION OF SIRUPS WHICH CONTAIN 2 PER CENT OR MORE OF INVERT SUGAR, STARCH SUGAR, OR RAFFINOSE, AS ALSO OF SUGARS CONTAINING RAFFINOSE.

[Official German method used in taxing sugars.]*

In the examination of those sirups, which have been handed over to the chemist because they contain 2 per cent or more of invert sugar, the determination of the specific gravity and degree Brix can be made as directed in Article A. Naturally the direct determination of the specific gravity by means of the picnometer can take the place of this method, but in no case is it allowable to substitute the estimation of total solids, as on the one hand this would cause differences in the coefficient of purity as obtained by the officers and chemists, and on the other hand the determination of total solids in sirups containing invert sugar is much too difficult and takes up too much time to be of any use in every-day practice. In calculating the coefficient of purity the method used in the sugar-house, namely, considering only sucrose as sugar, can not be used, but the invert sugar must be calculated as sucrose by deducting one-twentieth of the amount found, adding to the direct content of sucrose and basing the calculation on this result.

For the determination of the sugar-content various methods can be applied according to the amount of invert sugar, starch sugar, or raffinose present. The following remarks will offer some explanation:

The invert sugar of sirups is very often inactive, but can nevertheless have the power of rotating to the left, which deviation according to late investigations is 0.33, according to others 0.34 times as great as the right-handed rotation of sucrose. Consequently, as soon as considerable invert sugar is present, the polarization of the sucrose present will be correspondingly diminished. As is well known Meissl proposed in the examination of colonial sugars to multiply the invert sugar found by 0.34, add this to the polarization, and thus arrive at the correct amount of sucrose. This method would, however, be out of place in the analysis of sirups, as the invert sugar present very often does not show its normal rotatory power, but varies down to complete inactivity. Meissl's correction in such cases would lead to unreliable results. At the same time the rotatory power of the invert sugar may cause the results to be too low. In considering all these circumstances it becomes obvious that the determination of total sugar from the polarization and the invert sugar found is only possible when the invert sugar present does not exceed a certain percentage. For instance, if 6 per cent of invert sugar were present the amount of sucrose could be $6 \times 0.33 = 1.98$ per cent too low. Therefore, as the sirups handed to the chemist for examination may contain considerable quantities of invert sugar whose rotatory power we do not know, we recommend the rejection of the optical method completely, and the adoption of a gravimetric one, a new and easy modification of which will be given under I.

The presence of starch sugar or raffinose makes a difference. The reducing power of starch sugar, which in the commercial article presents a variation corresponding to from 40 to 60 per cent of sugar, is not changed by the conditions under which the inversion of sugar sirups is made in the gravimetric method; and as we can not determine the quantity of starch sugar present accurately, the gravimetric method for the estimation of the total content of beet sugar and of the quotient of purity is no longer applicable. It would on the contrary lead to large errors, and sirups having a coefficient of purity of over 70 would, if examined by this method, after the addition of a certain quantity of starch sugar, appear to be below 70. In

* Zeit. Anal. Chem., Vol. 28, No. 2.

such cases, where starch sugar is present, the influence exerted by the laevo-rotation of the invert sugar upon the polarization can no more be considered, as starch sugar has a higher dextro-rotatory power than the other sugars present. To avoid mistakes, which could be easily caused by adding starch sugar to sirups of a coefficient of purity of over 70, it is best, when starch sugar is present, to calculate the real sucrose content from the polarization and the invert sugar directly determined. This method is described under II. If raffinose is present still another method, which will be found under III, must be adopted.

I.—The presence of starch sugar need not be considered.

The examination of sirups which do not contain any starch sugar sirup, will be a common occurrence, as such an addition is generally not made by the manufacturers themselves, but rather by the dealers. One operation will here suffice for the determination of total sugar.

Weigh out one-half the normal weight (13.024 grams) of sirup, dissolve in a 100 cubic centimeter flask in 75 cubic centimeters of water, add 5 cubic centimeters hydrochloric acid (38.8 per cent HCl), and warm in a water bath to 67° to 70° C. As soon as the contents of the flask have reached this temperature, heat for five minutes, not allowing the temperature to rise above 70° C., and shaking frequently. As the previous warming will take from two and a half to five minutes, the whole operation will require from seven and a half to ten minutes. Fill up to the mark, shake, and dilute 50 cubic centimeters of this solution to a liter. By means of a pipette transfer 25 cubic centimeters of this to a flask and add 25 cubic centimeters of a solution of sodium carbonate (1.70 grams anhydrous salt to the liter) to neutralize the free acid present. Add 50 cubic centimeters of Soxhlet's solution, heat to boiling, as in the determination of invert sugar, and keep the liquid in ebullition for three minutes. As all the sucrose in this solution has been inverted, and is therefore unable to influence the result, we need not be so careful about the time of boiling. Soxhlet's experiments show that two or three minutes difference will not influence the result materially. Dilute the liquid with an equal volume of water, which has been previously boiled so as to expel air, and continue as directed under the determination of invert sugar. The tables so far published for the calculation of results are of no value in this case, as they have been constructed with regard to glucose or a mixture of invert sugar and saccharose. The following table has been compiled for invert sugar and enables the analyst to calculate the amount of sucrose directly from the amount of copper found.

Table for calculating the sucrose corresponding to the invert sugar present from the copper found on three minutes' boiling.

Sucrose. Mg.	Copper. Mg.	Sucrose. Mg.	Copper. Mg.	Sucrose. Mg.	Copper. Mg.	Sucrose. Mg.	Copper. Mg.
40	79.0	73	145.2	106	208.6	139	269.1
41	81.0	74	147.1	107	210.5	140	270.9
42	83.0	75	149.1	108	212.3	141	272.7
43	85.2	76	151.0	109	214.2	142	274.5
44	87.2	77	153.0	110	216.1	143	276.3
45	89.2	78	155.0	111	217.9	144	278.1
46	91.2	79	156.9	112	219.8	145	279.9
47	93.3	80	158.9	113	221.6	146	281.6
48	95.3	81	160.8	114	223.5	147	283.4
49	97.3	82	162.8	115	225.3	148	285.2
50	99.3	83	164.7	116	227.2	149	286.9
51	101.3	84	166.6	117	229.0	150	288.8
52	103.3	85	168.6	118	230.9	151	290.5
53	105.3	86	170.5	119	232.8	152	292.3
54	107.3	87	172.4	120	234.6	153	294.0
55	109.4	88	174.3	121	236.4	154	295.7
56	111.4	89	176.3	122	238.3	155	297.5
57	113.4	90	178.2	123	240.2	156	299.2
58	115.4	91	180.1	124	242.0	157	300.9
59	117.4	92	182.0	125	243.9	158	302.6
60	119.5	93	183.9	126	245.7	159	304.4
61	121.5	94	185.8	127	247.5	160	306.1
62	123.5	95	187.8	128	249.3	161	307.8
63	125.4	96	189.7	129	251.2	162	309.5
64	127.4	97	191.6	130	252.9	163	311.3
65	129.4	98	193.5	131	254.7	164	313.0
66	131.4	99	195.4	132	256.5	165	314.7
67	133.4	100	197.3	133	258.3	166	316.4
68	135.3	101	199.2	134	260.1	167	318.1
69	137.3	102	201.1	135	261.9	168	319.9
70	139.3	103	202.9	136	263.7	169	321.6
71	141.3	104	204.8	137	265.5	170	323.3
72	143.2	105	206.7	138	267.3		

Example: 25 cubic centimeters of the solution = 0.1628 grams substance, gave 0.1628 grams of copper, which corresponds to 0.032 grams of sugar. Therefore the sirup contained 50.4 per cent sugar.

Supposing that this sirup showed 80° Brix, then its coefficient would be 63. This coefficient is only calculated to tenths, hundredths in the case of the degree Brix being taken as an additional tenth, while with the coefficient they are not considered, thus 82.85 Brix would be read 82.9, while a coefficient of 69.99 is taken as 69.9 and not 70.

II.—The sirup to be examined may contain starch sugar.

In this case a direct polarization must first be made. If this gives a coefficient of purity above 70, further examination is unnecessary, as it would only tend to raise the coefficient, never to lower it.

If, however, the coefficient falls below 70, the presence of starch sugar is still possible. To determine whether any is present the sirup is inverted as in I, and made up to the mark.

It is then decolorized by adding $\frac{1}{2}$ to 1, in the case of dark sirups from 2 to 3 grams of bone charcoal previously washed with hydrochloric acid or of charred blood. If the latter is used, its absorption factor for invert sugar must be previously determined, and a corresponding correction in the polarimetric reading made in case the left-handed rotation is to be estimated accurately. In the present case it is sufficient to approximately determine this rotation at about 20°. Experience has shown that unadulterated sirups do not always have a laevo-rotation corresponding to 0.33 of the original right-handed rotation, but in all cases it is at least one-fifth of the original reading. A sirup polarizing 55 directly should, after inversion, read at least -11, calculated for normal weight. If this sirup should read -10 or less, or should even rotate to the right, then it has been adulterated with starch sugar. When the absence of starch sugar has thus been proved the sirup must be examined according to I.

If, however, starch sugar is present, then we must arrive at the total sucrose by adding to the direct polarization the invert sugar found by Fehling's solution. In this procedure the Fehling's solution is used according to Soxhlet's directions, but as the amount of solution taken by this author would not suffice for 10 grams of substance, we have to make preliminary experiments to determine the quantity of sirup which should be taken. This is done most easily by diluting 10 grams sirup to 100 cubic centimeters, placing 5 cubic centimeters of Fehling's solution into several test tubes and adding successively 8, 6, 4, and 2 cubic centimeters of the sirup solution. Upon boiling we will arrive at a point where the Fehling's solution is no longer decolorized. If this is the case with 6 cubic centimeters then 6 grams of substance are weighed out, dissolved in 50 cubic centimeters of water, and 50 cubic centimeters of Fehling's solution added. The whole is boiled for two minutes and the analysis conducted as in the estimation of invert sugar.

The invert sugar is calculated according to Meissl's table. The following data concerning the use of the table are taken from the original article, *Zeitschrift des Vereines für die Rübenzuckerindustrie des Deutschen Reiches*, 1883, p. 768:

Let

$$\text{I. } \frac{\text{Cu}}{2} = \text{approximate absolute amount invert sugar} = Z;$$

$$\text{II. } Z \times \frac{100}{p} = \text{approximate per cent invert sugar} = y;$$

$$\text{III. } \frac{100 \text{ Pol.}}{\text{Pol.} + y} = R, \text{ relative number for sucrose};$$

$$100 - R = I, \text{ relative number for invert sugar};$$

$$R:Z, \text{ relation of sucrose to invert sugar} = 6;$$

$$\text{IV. } \frac{\text{Cu}}{p} \times F = \text{correct percentage of invert sugar.}$$

In these formulas Cu is the weighed copper,

p the amount of substance taken,

Pol. the polarization,

Z facilitates reading the vertical column, and $R:Z$ the horizontal column of the following table.

To use the table find the columns agreeing most closely with the values found for Z and $R:Z$. When these columns meet the value of factor F will be found.

Factors for the determination of invert sugar in the presence of sucrose.

Sucrose : invert sugar = R : Z.	Milligrammes invert sugar = Z.									Factors = F.
	245	225	200	175	150	125	100	75	50	
90 : 10	56.2	55.1	54.1	53.6	53.1	52.6	52.1	51.6	51.2	
91 : 9	56.2	55.1	54.1	53.6	52.6	52.1	51.6	51.2	50.7	
92 : 8	56.2	54.6	53.6	53.1	52.1	51.6	51.2	50.7	50.3	
93 : 7	55.7	54.1	53.6	53.1	52.1	51.2	50.7	50.3	49.8	
94 : 6	55.7	54.1	53.1	52.6	51.6	50.7	50.3	49.8	48.9	
95 : 5	55.7	53.6	52.6	52.1	51.2	50.3	49.4	48.9	48.5	
96 : 4 .....	.....	.....	52.1	51.2	50.7	49.8	48.9	47.7	46.9	
97 : 3 .....	.....	.....	50.7	50.3	49.8	48.9	47.7	46.2	45.1	
98 : 2 .....	.....	.....	49.9	48.9	48.5	47.3	45.8	43.3	40.0	
99 : 1 .....	.....	.....	47.7	47.3	46.5	45.1	43.3	41.2	38.1	

Example: The polarization of a sugar is 86.4 and 3.256 grams substance = p is equivalent to 0.290 grams copper = Cu, then:

$$\text{I. } \frac{\text{Cu}}{2} = \frac{0.290}{2} = 0.145 = Z;$$

$$\text{II. } Z \times \frac{100}{p} = 0.145 \times \frac{100}{3.256} = 4.45 = y;$$

$$\text{III. } \frac{100 \times \text{Pol.}}{\text{Pol.} + y} = \frac{8640}{86.4 + 4.45} = 95.1 = R;$$

$$100 - R = 100 - 95.1 = 4.9; R:Z = 95.1:4.9.$$

By consulting the table we find that column 150 comes nearest to $Z = 145$ and column 95 : 5 is nearest to $R : Z = 92.1 : 4.9$.

Where these columns meet we find the factor 51.2, which enters into the last calculation.

$$\text{IV. } \frac{\text{Cu}}{p} \times F = \frac{0.290}{3.256} \times 51.2 = 4.56 \text{ per cent invert sugar.}$$

To convert this into saccharose, we subtract $\frac{1}{20}$; $4.56 - 0.23 = 4.33$; add this figure to the direct polarization and calculate the coefficient of purity from this and the degree Brix.

III.—*The presence of raffinose must be considered.*

If the chemist is required to consider the presence of raffinose he must proceed as follows:

(a) The direct polarization of the sugar is determined, as also (b) the indirect polarization at exactly 20°C .

The same precautions must be taken in making the inversion as in I and II. Half the normal weight is dissolved in 75 cubic centimeters of water in a 100 cubic centimeter flask, 5 cubic centimeters hydrochloric acid (38.8 per cent HCl) added and heated for seven and one-half to ten minutes to 60 to 70°C . After making up to the mark and clarifying with washed bone-black, the reading is taken at exactly 20°C . The following formula serves to calculate the result:

$$Z \text{ (sugar)} = \frac{0.5188 P - J}{0.845} \text{ and } R \text{ (raffinose)} = \frac{P - Z}{1.85},$$

when P = direct polarization and J = invert reading for normal weight, the prefixed sign having been changed.

The invert sugar is determined as in other sirups. If the test described in Article A shows it to be present in quantities of less than 2 per cent, then it need not be further considered. 2 per cent or more of invert sugar must be determined quantitatively according to Meissl's method described in II and calculated as saccharose. In finding the factor of this table, raffinose is to be considered as sucrose and Meissl's value. Pol. is therefore the sum of sucrose and raffinose. The coefficient of purity is calculated from the degree Brix and the total sucrose (that is sucrose + invert sugar calculated to sucrose), the raffinose not being considered.

Example: The examination of a sirup gave 85.6° Brix, 76.6 direct polarization, —3 Pol. after inversion. By using the above formula we find 50.5 sucrose and 14 raffinose. There were also found 2.1 per cent. sucrose as invert sugar. Therefore the total sucrose is 52.6 and the coefficient 61.4.

Rank deceptions might be practiced by adding small amounts of starch sugar sirup to very pure sirups and requesting an examination with regard to raffinose present. In such cases the above method would cause an error in finding too small a sugar content and a considerable amount of raffinose corresponding to the starch sugar added.

The application of this method for the examination of sirups supposed to contain raffinose is hence only possible when no starch sugar is present. If starch sugar is known to be present, then the method described in II must be used.

The estimation of starch sugar can not be made exactly as described in II for sirups in general, as sirups containing raffinose give a different invert reading.

If, therefore, a product is to be examined which is supposed to contain raffinose, it is best to use method No. III, and calculate sucrose and raffinose from this. The observed readings should not vary more than $\pm 5^{\circ}$ from the calculated readings, otherwise starch sugar is certainly present and the raffinose formula no more applicable. In such a case the sirup must be examined according to II.

IV.—*Examination of sugars for raffinose.*

The method of examining sirups containing raffinose can be applied to sugars. The direct polarization is taken in the usual manner, the indirect after inversion of one-half the normal weight just as directed for sirups under III (*b*) and the content of sucrose and raffinose calculated by means of the formula given in III. Numerous experiments have shown this method to give reliable results. Thus there were found in mixtures of sucrose and raffinose :

Mixture.		Found by the method.	
Sucrose.	Raffinose.	Sucrose.	Raffinose.
<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
97.00	3.00	97.02	2.98
91.00	9.00	90.99	8.95
85.00	15.00	85.06	14.97

Though without doubt this method is very accurate, still a wide limit must be given for experimental errors on account of its novelty. A variation of 0.6 between the sucrose as calculated by the raffinose formula and that determined directly by polarization has therefore been made the limit. Supposing, for instance, that the sucrose found by direct polarization is 92.6 and that calculated by the formula 92 per cent, then we may suppose this difference to be caused by errors in the method. In such a case raffinose should be reported absent and the direct polarization used for the sugar content. If, however, only 91.9 per cent sucrose were found by the formula while the direct polarization was 92.6, then the presence of raffinose can not be doubted. To avoid mistakes which may be caused by larger errors than 0.6, it is advisable to make a control determination in all cases where the difference is less than 1 per cent, and to base the presence or absence of raffinose upon the result of this control.

The above limit for errors will not influence the utility of the method, as the percentage of raffinose so far observed in high sugars always corresponded to more than 0.6 per cent of sucrose. No method has yet been proposed for the determination of smaller amounts of raffinose and they may therefore be neglected. Scheibler's method of calculating small amounts of raffinose by supposing the organic substances not sugar to be equal to the ash is not accurate, as the excess of organic substance over ash is not known.

The method is, however, of value in cases where the result found by the formula varies comparatively little from the polarization ; for instance, corresponding to less than 1 per cent of sucrose. Here it will decide whether raffinose is present or whether the difference is caused by errors.

For this purpose the polarization, moisture, and ash are determined, the organic substances not sugar taken as equal to the ash, and these four constituents added together. In all cases where raffinose is present the result will be over 100 ; if it falls below 100, raffinose may be considered absent. In the former case, the percentage of raffinose is calculated as follows :

The percentage of water plus twice the ash is deducted from 100.

The result corresponds to the percentage of sucrose plus anhydrous raffinose. If we substitute *a* for the figure thus found, *p* for the direct polarization, *x* for the sucrose present, and *y* for the raffinose present, then.

$$\begin{aligned}
 x + 1.85 y &= p \\
 x + y &= a \\
 x (\% \text{ sucrose}) &= \frac{1.85 a - p}{0.85} \\
 y (\% \text{ raffinose}) &= \frac{a - 1.85 a - p}{0.85}.
 \end{aligned}$$

The limit for error must here be placed at 0.3; that is, the sum of polarization, twice the ash and moisture must be more than 100.3, if the method is employed. Otherwise the result would be too uncertain for practice, as errors of 0.2 may easily occur in the direct reading. The following example has been so constructed as to show that the method with the above limit of error is not capable of determining variations of 0.6 per cent.

A sugar gave 99.7 polarization, 0.4 water, and 0.1 ash; then the sum total was:

$$\begin{array}{rcl}
 & 99.7 & a = 100.0 \\
 & + 0.4 & - 0.4 \\
 + 2 \times 0.1 = 0.2 & & - 0.2 \\
 \hline
 & 100.3 & a = 99.4 \quad p = 99.7
 \end{array}$$

Therefore x (sucrose) = 99.05, which is taken as 99.1, and y (raffinose) = 0.3. It is apparent that the 0.3 plus polarization, found by this method, and which must be taken as the limit of error, correspond exactly to the variation between actual sucrose and direct reading, which has been made the limit for the inversion method with raffinose formula. The control is unnecessary when a difference of 1 per cent or more is found between the actual sucrose and direct reading. Very often the result of the raffinose formula is taken even if the control gives a negative result. If Scheibler's method gives negative results with a sugar varying less than 1 per cent, then raffinose should be reported absent. If, however, the control leaves any doubt, as when the sum varies between 100 and 100.3, or if raffinose is actually found, then the results obtained by the inversion method should always be reported, as long as the difference between the sucrose found and the direct reading amounts to more than 0.6 per cent. If it is less than 0.6 or just 0.6, then the analyst should report that he is unable to detect raffinose. In calculating the final result hundredths should be taken as an additional tenth; thus, 97.01 per cent sucrose is 97.1.

PLAN B.—OFFICIAL INSTRUCTIONS FOR THE EXAMINATION OF CHOCOLATE, CANDIES, AND LIQUORS FOR THE QUANTITY OF SUCROSE CONTAINED THEREIN.

A. The examination, especially of chocolate, preserved fruits, and liquors, must be primarily directed toward the detection of starch sugar, or honey.

B. The Soleil-Ventzke saccharimeter is used in the sucrose determinations. The directions for the use of the instrument will be found in Plan C of the official bulletin published as an appendix to the sugar-tariff law of July 9, 1887.

Ventzke's scale is so arranged that a 200-millimeter tube filled with a sugar solution containing 26.048 grams per 100 cubic centimeters will read 100.

If 26.048 grams of a substance are weighed out, dissolved in 100 cubic centimeters of water and polarized in a 200-millimeter tube, the number of degrees read on the scale will be the per cent by weight of sugar in the material.

The same is the case when 13.024 grams are dissolved in 50 cubic centimeters. If this weight (one-half normal weight) has been dissolved in 100 cubic centimeters the reading of the polariscope must be doubled.

If any other quantity (p grams) was weighed out, dissolved in 100 cubic centimeters and polarized in the 200-millimeter tube, the number of degrees read on the scale (a) $\times$ 0.26048 will give the grams sucrose in 100 cubic centimeters of the solution, and

$$\frac{26.048 \cdot a}{p}$$

will give the per cent sucrose in the substance analyzed.

In all cases where the substance to be examined contains no other optically active bodies, the direct polarization will give accurate results. If such are present, as for instance glucose, invert sugar, maltose, dextrin, pectinous bodies, the application of the polariscope becomes uncertain, and only in a few cases, which will be given below, can somewhat reliable results be obtained.

As regards the preparation of the solutions the following must be remembered: Material which consists mostly of sucrose and leaves only a small residue on being

treated with water, can be weighed out in the dish, and the solution immediately transferred to the sugar flask. When the substance, however, contains much insoluble matter, the latter should not be washed into the flask, as the volume of the sugar solution in such a case would be less than 100 cubic centimeters. In this case the residue must be separated from the solution by filtration and washing. Generally the sugar solution is not quite transparent and must be treated with some clearing agent. The solutions serving this purpose are:

(1) Lead acetate, of which from 1 to 10 cubic centimeters are mixed with the solution and the latter filtered after standing from one-fourth to one-half an hour.

(2) Lead acetate with subsequent addition of alum or aluminum sulphate, the lead sulphate formed carrying down the foreign matter.

(3) Aluminum hydrate in the form of a thin paste, of which several cubic centimeters are shaken with the solution.

(4) Tannic acid to precipitate albuminous substances. This must be examined beforehand with regard to its optical activity.

(5) Charred blood or boneblack to remove coloring matter, $\frac{1}{2}$ to 1 gram, are added to the liquid.

In some cases this clearing is difficult and the method best adapted must be determined by previous experiments. For solutions prepared from candies the pasty aluminum hydrate is the best medium.

When, as it is often the case, invert sugar is present, the result of the direct polarization will be too low on account of the left-handed rotation of this sugar. In such a case Clerget's inversion method must be applied to find the correct per cent of sucrose. This is conducted as follows: 26.048 grams are dissolved in a sugar flask and the solution made up to 100 cubic centimeters; 50 cubic centimeters of this solution are transferred by means of a pipette to a 50 or 55 cubic centimeter flask, cleared and polarized, the reading being corrected for the extra 5 cubic centimeters. The liquid adhering to the pipette is washed into the 100 cubic centimeter flask containing the remaining 50 cubic centimeters (13.024 grams), 5 cubic centimeters of concentrated hydrochloric acid (38 per cent, specific gravity 1.88 at 15° C.) added and the flask heated for fifteen minutes at 67° to 70° C. in a water bath. The temperature should not exceed this limit. The flask is then cooled rapidly and the solution made up to 100 cubic centimeters. If the liquid is colored, it is shaken with $\frac{1}{2}$ to 1 gram of bone-black and filtered through a double filter. It is then polarized in a 200-millimeter tube which is provided with a thermometer. As the rotatory power of invert sugar is much influenced by the temperature, this factor must be regarded. The reading is best taken between 18° and 22° C. and the temperature accurately determined. The reading must also be doubled on account of the dilution of the liquid.

To calculate per cent of sucrose (R) the two readings are added together, the sum (S) multiplied by 100 and divided by $142.4 - \frac{1}{2}t$ where t is the temperature at which the invert reading was taken. If the temperature is exactly 20° C., the result can be made more accurate by substituting 142.66 for 142.4, thus:

$$R = \frac{100 S}{142.66 - \frac{1}{2}t} = \frac{100 S}{132.66} = 0.7538 S.$$

If very much invert sugar is present, both the direct and indirect readings must be taken at the same temperature.

I.—Chocolate.

Weigh out in a German silver dish 13.024 grams of the rasped chocolate, moisten with alcohol (to aid the solution in water), add 30 cubic centimeters of water, and heat for ten to fifteen minutes on the water bath. Filter while warm into a 100 to 110 cubic centimeter flask, using a folded filter, any turbidity of the filtrate not being of any consequence. The residue on the filter is washed with hot water until the filtrate amounts to about 100 cubic centimeters. Five cubic centimeters of lead

acetate are then added, the liquid allowed to stand fifteen minutes, and a few drops of alum solution and some moist aluminum hydrate added. The liquid is then made up to 110 cubic centimeters, shaken well, and filtered through a folded filter. Slight moistening of the filter will aid filtration, but the first 25 cubic centimeters of filtrate should then be rejected. The polarization should be increased by one-tenth and then doubled.

II.—Candies and confectionery.

(a) *Dragees* (seeds or kernels coated with sugar and flour).—26.048 grams are covered in a beaker with 40 to 50 cubic centimeters of water and allowed to stand, stirring now and then, until the mass is completely saturated. If the liquid shows an acid reaction, some precipitated calcium carbonate or a few drops of ammonia are added. The larger particles are now separated by filtering through cloth, the filtrate being collected in a 100 to 110 cubic centimeters flask. The residue on the filter is washed with cold water until about 100 cubic centimeters of filtrate have accumulated. Some aluminum hydrate is then added to clear it, the solution made up to 110 cubic centimeters with water, and about half a gram of bone-black added in case the liquid is colored. It is then allowed to stand half an hour, with occasional shaking. The solution is finally filtered through a dry folded filter.

A preliminary test for invert sugar is made with copper sulphate and soda lye, and the solution analyzed accordingly. Dragees almost always contain invert sugar.

(b) *Raffinade wafers* (cane sugar, with ethereal oils and coloring matter).—26.048 grams dissolved in water, made up to 100 cubic centimeters in flask, and, if necessary, decolorized with bone-black. A preliminary test for invert sugar must always be made and the analysis directed accordingly.

(c) *Santonin wafers* (worm wafers, cane sugar, with santonin and some agglutinant, as egg albumen).—13.024 grams dissolved in a 100 cubic centimeter flask (the santonin being insoluble), 5 cubic centimeters of lead acetate added, with a few drops of alum solution, the solution allowed to stand some time, with occasional shaking, made up to 100 cubic centimeters and filtered.

(d) *Dessert bonbons* (Fondant's, Pralinee's, chocolate bonbons, consisting of cane sugar or invert sugar, serving as a covering for marmalade, fruit, or chocolate).—13.024 grams are treated with water and a few drops of ammonium hydrate until dissolved. If only a slight residue remains the whole can be immediately transferred to a 100 cubic centimeter flask, otherwise it must first be filtered. One-half of the liquid is inverted, the other polarized directly after having been cleared by means of aluminum hydrate in a 50 to 55 cubic centimeter flask.

(e) *Marzipan Masse* (cane sugar, with crushed almonds).—13.024 grams material are triturated in a porcelain mortar with cold water, then mixed in a flask with 50 cubic centimeters of water and about 30 cubic centimeters of pasty aluminum hydrate, well shaken and filtered into a 200 cubic centimeter flask. The residue on the filter is washed with water until the filtrate amounts to 200 cubic centimeters. As this candy contains no invert sugar the solution can be polarized directly in the 200 millimeter tube, the reading being multiplied by 4 to correct for the dilution.

(f) *Cakes and sweetened pastry*.—26.048 grams of the powdered material are mixed in a flask with about 75 cubic centimeters alcohol (85 to 90 per cent) and allowed to stand one-half hour in a warm place. It is then filtered through a fine cloth filter and the residue washed several times with alcohol. The filtrate is collected in a porcelain dish and heated on the water bath until the alcohol has all been driven off. One-half gram bone-black is then added and the solution filtered into a 100 cubic centimeter flask. 50 cubic centimeters are used for inversion, the remainder polarized directly.

(g) *Sugar-coated and preserved fruits* (marmalade, compots, jellies).—A considerable amount of invert sugar and pectinous bodies are always present. The aqueous solution of the latter has no rotatory power. If the material is solid in consistence, a crushed

or finely cut average sample must be prepared. 13.024 grams are then mixed with 30 to 50 cubic centimeters of water and a few drops of ammonium hydrate (to neutralize any free vegetable acids) and allowed to stand several hours. It is then passed through a cloth filter into a 100 or 200 cubic centimeter flask, the residue washed several times with hot water, and about 10 cubic centimeters of aluminum hydrate and one-half gram bone-black added to the filtrate. It is then shaken and made up to the mark. After filtering the filtrate is polarized according to Clerget's method.

Fruit jellies and marmalade are analyzed in a similar manner.

If the sucrose articles enumerated under II, g was calculated by the formula

$$R = \frac{100 S}{142.4 - \frac{1}{2} t'}$$

we would only obtain the percentage present at the time of analysis. The acids of the fruit have, however, converted a large amount of the cane sugar originally used into invert sugar. The original percentage of cane sugar, which is taken as a basis for taxation by the custom-house, can be calculated from the reading of the inverted solution. If this reading is referred to 26.048 grams material dissolved in 100 cubic centimeters and polarized in a 200 millimeter tube, we have the following relations if the above figure is called B :

A solution of 26.048 grams of cane sugar in 100 cubic centimeters has, after inversion, at the temperature t° the left-handed rotation $42.4 - \frac{1}{2} t$. The amount of cane sugar corresponding to the observed polarization B can thus be calculated by the proportion:

$$42.4 - \frac{1}{2} t : 26.048 = B : \frac{26.048 \cdot B}{42.4 - \frac{1}{2} t}$$

and this is contained in 26.048 grams of the material used. Therefore the original percentage r of cane sugar can be calculated from the second proportion.

$$26.048 : \frac{26.048 \cdot B}{42.4 - \frac{1}{2} t} = 100 : r$$

whence

$$r = \frac{100 B}{42.4 - \frac{1}{2} t}$$

If 13.024 grams substance were used and the solutions polarized at exactly 20°C. , then the following formula is more accurate:

$$r = \frac{100 B}{42.66 - 10} = 3.062 B.$$

III.—Liquors.

The percentage of sugar in liquors is generally expressed as grams per liter.

Every liquor must be previously tested for invert sugar by diluting a little in a test tube with water, adding five drops of copper sulphate solution and enough sodium hydrate to form a clear blue liquid. If no change occurs upon heating, cane sugar only is present; a yellow or red precipitate indicates the presence of other sugars.

Liquors which do not contain invert sugar may be polarized directly in the 200 millimeter tube, being previously decolorized with bone-black if necessary. If a high percentage of sugar is present, the polarization must be made in the 100 millimeter tube.

The presence of alcohol has no influence on the reading. The ethereal oils which are present, although optically active, are present in such small quantities as to be without influence. The grams per liter (R) are found, when A is the reading in a 200 millimeter tube, by: $R = 2.6048 A$.

When invert sugar is present, the alcohol must be removed, as it materially changes the rotation of this sugar.

Fifty cubic centimeters of liquor are measured into a porcelain dish and evaporated to about one-half the volume on a water bath. If the liquid has an acid reaction, a few drops of ammonium hydrate must be added before heating it. The residue is washed into a 100 cubic centimeter flask and made up to the mark with water. One-half is then polarized directly, the other after inversion. Both solutions may have to be decolorized with bone-black.

Supposing

V = number of cubic centimeters used for analysis,

A = direct reading,

B = reading of inverted solution (both read in 200 millimeter tube),

t = temperature of inverted solution when polarized;

then the grams of cane sugar (R) in a liter may be calculated from the formula :

$$R = \frac{26.048 (A - B)}{(142.4 - \frac{1}{2} t) V},$$

where, when the direct reading was +, the inverted reading —, the difference A — B becomes A + B.

If the temperature was exactly 20° C.,

$$R = 196.7 \frac{A + B}{V}, \text{ or more accurately } = 196.35 \frac{A + B}{V}$$

In liquors, as under III, *b*, the addition of the fruit juices may have caused inversion of a part of the cane sugar originally added. The original percentage of cane sugar is then calculated from the inverted reading just as for candied fruits. The grams of cane sugar (*r*) per liter are found from :

$$r = \frac{26.048 B}{(42.4 - \frac{1}{2} t) V},$$

or when $t = 20^\circ$,

$$r = 804 \frac{B}{V} \text{ or more accurately } = \frac{26.048 B}{32.66 V} = 797.55 \frac{B}{V}.$$

PLAN C.—DIRECTIONS FOR DETERMINING THE BONIFICATIOUS VALUE OF INVERT SUGAR SIRUP.

While the sirup is being barreled a number of samples are taken so as to obtain a good average. This is well mixed and 250 grams weighed out in a tared beaker. After dissolving in distilled water the beaker is placed on the balance and enough water added to bring the weight of sirup and water up to 1000 grams. The sirup has then been diluted with three times its weight of water. The solution is again well mixed with a glass rod and poured into a high cylinder. A special spindle is used to determine the percentage of invert sugar. This spindle is used similarly to the Brix spindle for analyzing sirups. It is graduated at $17\frac{1}{2}^\circ$ C., and the following table is used to correct for the temperature :

Subtract from the reading.		Add to the reading.		Add to the reading.	
At 10° C.	0.35° Brix.	At 18° C.	0.03° Brix.	At 25° C.	0.50° Brix.
11° C.	0.29° Brix.	19° C.	0.09° Brix.	26° C.	0.57° Brix.
12° C.	0.25° Brix.	20° C.	0.17° Brix.	27° C.	0.64° Brix.
13° C.	0.22° Brix.	21° C.	0.24° Brix.	29° C.	0.71° Brix.
14° C.	0.18° Brix.	22° C.	0.31° Brix.	29° C.	0.79° Brix.
15° C.	0.14° Brix.	23° C.	0.38° Brix.	30° C.	0.87° Brix.
16° C.	0.10° Brix.	24° C.	0.44° Brix.		
17° C.	0.04° Brix.				

The reading is multiplied by 4 to obtain the per cent of invert sugar in the undiluted sirup. Hundreths are always read as an additional tenth.

Example: The spindle read 18.1 per cent invert sugar at 20°. Hence 0.17° must be added to the reading and the sum multiplied by 4.

$$18.1 + 0.17 = 18.27 \times 4 = 73.08, \text{ or } 73.10.$$

The weight of the cane sugar used in the preparation of the sirup is then calculated by subtracting $\frac{1}{20}$ and multiplying the result by the weight of the invert-sugar sirup.

METHODS FOR DETERMINING PHOSPHORIC ACID AND MOISTURE.

(1) *Preparation of sample.*—The sample should be well intermixed and properly prepared and passed through a sieve having circular perforations one twenty-fifth of an inch in diameter, so that separate portions shall accurately represent the substance under examination, without loss or gain of moisture.

(2) *Determination of moisture.*—(a) In potash salts, nitrate of soda, and sulphate of ammonia heat 1 to 5 grams at 130° C. till the weight is constant, and reckon water from the loss. (b) In all other fertilizers heat 2 grams, or if the sample is too coarse to secure uniform lots of 2 grams each, 5 grams, for five hours at 100° C. in a steam bath.

(3) *Water-soluble phosphoric acid.*—Weigh out 2 grams in a small beaker, wash by decantation four or five times with not more than from 10 to 15 cubic centimeters of water, then rub it up in the beaker with a rubber-tipped pestle to a homogeneous paste, and then wash four or five times by decantation with from 10 to 15 cubic centimeters of water. Transfer the residue to a 9 centimeter, No. 589 Schleicher and Schüll filter, and wash with water until the filtrate measures not less than 250 cubic centimeters. Mix the washings. Take an aliquot (corresponding to one-half gram) and determine phosphoric acid, as under total phosphoric acid.

(4) *Citrate-insoluble phosphoric acid.*—Wash the residue of the treatment with water into a 200 cubic centimeter flask with 100 cubic centimeters of strictly neutral ammonium citrate solution of 1.09 density, prepared as hereafter directed. Cork the flask securely and place it in a water bath, the water of which stands at 65° C. (The water bath should be of such a size that the introduction of the cold flask or flasks shall not cause a reduction of the temperature of the bath of more than 2° C.) Raising the temperature as rapidly as practicable to 65° C., which is subsequently maintained, digest for thirty minutes from the instant of insertion, shaking every five minutes, filter the warm solution quickly (best with filter pump), and wash with water of about the temperature of 65°. Transfer the filter and its contents to a capsule, ignite until the organic matter is destroyed, treat with 10 to 15 cubic centimeters of concentrated hydrochloric or nitric acid, digest over a low flame until the phosphate is dissolved, dilute to 200 cubic centimeters, mix, pass through a dry filter, take an aliquot and determine phosphoric acid as under total.

In case a determination of citrate-insoluble phosphoric acid is required in non-acidulated goods, it is to be made by treating 2 grams of the phosphatic material, without previous washing with water, precisely in the way above described, except that in case the substance contains much animal matter (bone, fish, etc.), the residue insoluble in ammonium citrate is to be treated by one of the processes described below.

(5) *Total phosphoric acid.*—Weigh 2 grams and treat by one of the following methods: (1) Evaporation with 5 cubic centimeters magnesium nitrate, ignition, and solution in acid. This method is to be used in case of all fertilizers containing cottonseed meal. (2) Solution in 30 cubic centimeters concentrated nitric acid with a small quantity of hydrochloric acid. (3) Add 30 cubic centimeters concentrated hydrochloric acid, heat, and add cautiously in small quantities at a time about 0.5 gram of finely pulverized potassium chlorate.

Boil gently until all phosphates are dissolved and all organic matter destroyed; dilute to 200 cubic centimeters; mix and pass through a dry filter; take 50 cubic

centimeters of filtrate; neutralize with ammonia (in case hydrochloric acid has been used as a solvent add about 15 grams dry ammonium nitrate or its equivalent). To the hot solutions for every decigram of P_2O_5 that is present, add 50 cubic centimeters of molybdic solution. Digest at about $65^\circ C.$ for one hour, filter and wash with water or ammonium nitrate solution. (Test the filtrate by renewed digestion and addition of more molybdic solution.) Dissolve the precipitate on the filter with ammonia and hot water, and wash into a beaker to a bulk of not more than 100 cubic centimeters. Nearly neutralize with hydrochloric acid, cool, and add magnesia mixture from a burette; add slowly (one drop per second), stirring vigorously. After fifteen minutes add 30 cubic centimeters of ammonia solution of density 0.95. Let stand several hours (two hours is usually enough). Filter, wash with dilute ammonia, ignite intensely for ten minutes, and weigh.

(6) *Citrate-soluble phosphoric acid*.—The sum of the water-soluble and citric-insoluble subtracted from the total gives the citrate-soluble.

PREPARATION OF REAGENTS.

(1) *To prepare ammonium citrate solution*.—Mix 370 grams of commercial citric acid with 1,500 cubic centimeters of water; nearly neutralize with crushed commercial carbonate of ammonia; heat to expel the carbonic acid; cool; add ammonia until exactly neutral (testing by saturated alcoholic solution of coralline) and bring to volume of two liters. Test the specific gravity, which should be 1.09 at $20^\circ C.$, before using.

(2) *To prepare molybdic solution*.—Dissolve 100 grams of molybdic acid in 400 grams or 417 cubic centimeters of ammonia of specific gravity 0.96, and pour the solution thus obtained into 1,500 grams or 1,250 cubic centimeters of nitric acid of specific gravity 1.20. Keep the mixture in a warm place for several days, or until a portion heated to $40^\circ C.$ deposits no yellow precipitate of ammonium phospho-molybdate. Decant the solution from any sediment, and preserve in glass stoppered vessels.

(3) *To prepare ammonium nitrate solution*.—Dissolve 200 grams of commercial ammonium nitrate in water and bring to a volume of 2 liters.

(4) *To prepare magnesia mixture*.—Dissolve 22 grams of recently ignited calcined magnesia in dilute hydrochloric acid, avoiding excess of the latter. Add a little calcined magnesia in excess, and boil a few minutes to precipitate iron, alumina and phosphoric acid; filter; add 280 grams of ammonium chloride, 700 cubic centimeters of ammonia of specific gravity 0.96, and water enough to make the volume of 2 liters. Instead of the solution of 22 grams of calcined magnesia 110 grams of crystallized magnesium chloride ($MgCl_2 + 6H_2O$) may be used.

(5) *Dilute ammonia for washing*.—One volume ammonia of specific gravity 0.96 mixed with three volumes of water, or usually one volume of concentrated ammonia with six volumes of water.

(6) *Nitrate of magnesia*.—Dissolve 320 grams of calcined magnesia in nitric acid, avoiding an excess of the latter; then add a little calcined magnesia in excess; boil; filter from excess of magnesia, ferric oxide, etc., and bring to volume of 2 liters.

METHODS OF ANALYSIS OF FERMENTED LIQUORS.

I. *Specific gravity*.—This determination is made with a pycnometer or a Westphal balance controlled by a pycnometer. Temperature $25^\circ C.$

II. *Alcohol*.—One hundred cubic centimeters of wine at $25^\circ C.$ distilled (preferably in glass) give + cubic centimeter alcohol.

III. *Extract*.—Fifty cubic centimeters of wine (at $25^\circ C.$), in case of sweet wines a less amount, are evaporated in a platinum dish on the water bath to the proper consistency and then dried in a drying oven at $100^\circ C.$ to constant loss of weight. Constant loss of weight is assumed when three weighings with equal intervals between the first and second and second and third give equal differences between the successive weighings. Weighings are to be made at intervals of fifteen minutes.

[NOTE ON THE EXTRACT DETERMINATION.—So far as I am aware no satisfactory method has been given for the determination of the extract of wine. I think that the method of the Bavarian chemists is on the whole the best. As the object is for purpose of comparison with some standard, we can not do better I think than to follow the standard most generally adopted. I have in mind when the new chemical laboratory of the University of California is fitted up to make some experiments on the determination of this extract in a vacuum at a moderate temperature. I should modify somewhat the method of Gautier. However, until some better method has been established, I believe the method given will be most satisfactory.]

IV. *Acidity* (total acid constituents of the wine expressed as tartaric acid).—If carbonic acid is present, expel by shaking. Titrate with dilute alkali solution. The neutral point is determined by adding a drop of solution to delicate litmus paper.

V. *Volatile acids* (expressed as acetic acid).—Distil in a current of steam and titrate the carefully condensed distillate with standard alkali (decinormal).

VI. *Glycerine*.—(1) This is determined in dry wines as follows: The alcohol is driven off from 100 cubic centimeters wine, lime or magnesia added, and the same evaporated to dryness. The residue is boiled with 90 per cent alcohol, filtered, and the filtrate evaporated to dryness. This residue is dissolved in 10 to 20 cubic centimeters alcohol, 15 to 30 cubic centimeters ether added, and the mixture allowed to stand until it is clear. It is then decanted from the sticky precipitate into a glass-stoppered weighing bottle, evaporated to constant loss of weight, and weighed.

(2) The following method is employed for sweet wines: One hundred cubic centimeters wine are measured into a porcelain dish and evaporated on the water bath to a sirupy consistence, mixed with 100 to 150 cubic centimeters absolute alcohol, poured into a flask, ether added in the proportion of $1\frac{1}{2}$ volumes to each volume of alcohol used, the flask well shaken, and allowed to stand until the liquid becomes clear. This is then poured off and the residue again treated with a mixture of alcohol and ether. The liquids are mixed, the alcohol and ether driven off, the residue dissolved in water, and treated as in (1).

(3) In all glycerine determinations it is necessary to take into consideration the loss of glycerine due to its volatility with water and alcohol vapor, and accordingly to add to the glycerine found 0.100 gram for each 100 cubic centimeters of liquid evaporated.

(4) It is necessary to test the glycerine from sweet wines for sugar, and if any is present it must be estimated by Soxhlet's or Knapp's method and its weight subtracted from that of the glycerine.

VII. *Sugar*.—This is to be determined by Soxhlet's or Knapp's method. The presence of unfermented cane sugar is to be shown by inversion, etc.

Polarization.—(1) The wine is decolorized with plumbic subacetate.

(2) A slight excess of sodic carbonate is added to the filtrate from (1). 2 cubic centimeters of a solution of plumbic subacetate are added to 40 cubic centimeters white wine and 5 cubic centimeters to 40 cubic centimeters red wine, the solution is filtered and 1 cubic centimeter of a saturated solution of sodic carbonate added to 21.0 or 22.5 cubic centimeters of the filtrate.

(3) The kind of apparatus used and the length of the tube are to be given, and results estimated in equivalents of Wild's polaristrobometer with 200 millimeter tubes.

(4) All samples rotating more than 0.5 degree to the right (in 220 millimeter tubes, after treating as above), and showing no change or but little change in their rotatory power after inversion, are to be considered as containing unfermented glucose (starch sugar) residue.

(5) Rotatory power of less than 0.3 degree to the right shows that impure glucose has not been added.

(6) Wines rotating between 0.3 degree and 0.5 degree to the right must be treated by the alcohol method.

(7) Wines rotating strongly to the left must be fermented and their optical properties then examined.

VIII. *Tannin*.—Determine with Neubauer's permanganate method.

IX. *Potassic bitartrate*.—The determination of potassic bitartrate as such is to be omitted.

X. *Tartaric, malic, and succinic acids*.—(1) According to Schmidt and Hiepe's method.

(2) Determination of tartaric acid according to the modified Berthelot-Fleury method.

(3) If the addition of 1 gram finely powdered tartaric acid to 100 grams wine produces no precipitate of potassic bitartrate, the modified Berthelot-Fleury method must be employed to determine free tartaric acid.

XI. *Coloring matter*.—(1) Only aniline dyes are to be looked for.

(2) Special attention is to be paid to the spectroscopic behavior of rosaniline dyes as obtained by shaking wines with amylic alcohol before and after saturation with ammonia.

XII. *Inorganic matter (ash)*.—Burn in ordinary manner in flat platinum dish at as low a heat as possible; repeated moistening, drying, and heating to redness are advisable to get rid of all organic substances.

XIII. *Citric acid*.—Presence to be shown by a qualitative test, as baric citrate.

XIV. *Sulphuric acid*.—To be determined in the wine after adding hydrochloric acid.

XV. *Chlorine*.—To be determined in the nitric acid solution of the burnt residue by Volhard's method.

XVI. *Lime, magnesia, and phosphoric acid*.—These are determined in the ash fused with sodic hydrate and potassic nitrate, the phosphoric acid by the molybdenum method.

XVII. *Potash*.—Either in the wine ash, as the platinum double salt, or in the wine itself, by Kayser's method.

XVIII. *Gums*.—Presence shown by precipitation by alcohol; 4 cubic centimeters wine and 10 cubic centimeters 96 per cent alcohol are mixed. If gum arabic has been added, a lumpy, thick, stringy precipitate is produced; whereas pure wine becomes at first opalescent and then flocculent.

XIX. *Sulphurous acid*.—One hundred cubic centimeters of wine are distilled in a current of carbonic acid after the addition of phosphoric acid. The distillate carefully condensed is oxidized with bromine and the amount of H_2SO_4 determined.

ABNORMAL CONSTITUENTS OF WINES.

Mannite.—When present in any considerable quantity it can be detected by simply allowing the wine (a few drops will be sufficient) to evaporate spontaneously upon a glass slide or plate. The mannite will crystallize in a characteristic stellated form, which can be recognized at a glance. It should be allowed to stand twenty-four to forty-eight hours. When the quantity is small extract the residue evaporated nearly or quite to dryness with boiling 80 per cent alcohol. Evaporate this extract to dryness and extract with 95 per cent boiling alcohol; the mannite if present in any quantity will separate out in part upon cooling. If allowed to evaporate spontaneously the characteristic stellated crystals can be obtained.

Lactic acid.—This will be found in the alcohol ether extract of evaporated residue and can be recognized by usual tests. It may be determined by titration with standard alkali. It may be necessary to take larger quantities of the wine for this investigation.

In diseased wines butyric acid may be tested for in the portion of volatile acid.

INDEX.

A.

	Page.
Acetate of lead, influence of precipitate of	138
Acetates, alkaline, effect on the inversion of sugar	136
Acids, standardization of	24
Adams method, application of	66
Aluminic phosphate, action of ammonic citrate on	170, 171
Ammonium citrate solution, experiments with	8
Ammonium molybdate, use of	153
Analyses, comparison of	128
Anderson, Mr. J. T., paper on analyses of cattle foods	93, 94
Apparatus, new forms for agricultural analyses	96
Arabinose, occurrence of	126
Ash analysis, importance of	9
estimation of	138
Association of Official Agricultural Chemists, committees of	185
constitution of	187, 188
officers of	185
primary object of	6
reporters of	185
Atwater, Mr. W. O., report on chemical study of foods and feeding stuffs....	117-125

B.

Babcock's method of determining fat in milk	34
accuracy of	40
apparatus and chemicals re-	
quired in	34-36
application of	41, 42
to cream	40
comparison of, with gravimetric	
method	41
expense of	42
measuring the fat in	39
method of applying	36-39
Benzine, degree of	51
Benzoic acid, use in ash determination	139
Bowman, Mr. Walker, resolution of	151
Burney, Mr. W. B., report of	153
Butter analyses, discussion of results of	49, 50
notes of analysts on	48, 49
proposed method of	47, 50
results of	48
determination of water, fat, casein, and salt in	46
preparation of samples of	47
weight of samples of	55

C.

	Page.
Caldwell, Mr. G. C., report of	79-90
Carbohydrates, character of	134, 135
in foods and feeding stuffs	122
Cattle foods, abstract of publications on	79-81
ash in	79, 85
analysis of	93
crude fiber in, analysis of	93
discussion of report on	106-108
division of	9
effect of methods and time of drying on analysis of	91, 92
ether extract in	80, 85-87
fiber in	81, 88
hygroscopic water in	84, 85
lack of agreement in analysis of	89, 90
methods of sampling for analysis	113
nitrogen, free extract of	81
notes of analysts on analyses of	84
object of analysis of	107
official method for the analysis of	211, 212
petroleum extract in	87
results of analyses of	82-84
size of sieve mesh to be used in preparation of samples of	115, 116
Causse, Mr. H., method of	137
Centrifugal milk test	61
Citrate method	153, 154
Citrates, alkaline, effect on the inversion of sugar	136
Clerget's process, explanation of	135, 136
Cochineal, use as indicator	25, 26
Cochran's method, comparison of	43
Columbian Exposition, laboratory at	151
committee on	151
Complete fertilizer, results of analyses of	157, 158
Cooke, Mr. W. W., table of comparative analyses	128
Copper solution, one-tenth, use of	136
Coralline, use as indicator	26
Cottonseed, lecithines in	95, 96
weight of fat in	96

D.

Dairy products, abstract of publications concerning	29-34
official method of determination of	195-211
request for bibliography of	64
Dancy, Mr. F. B., paper of	161
De Ghequier, Mr. A., address of	151, 152
Department of Agriculture, vote of thanks to	150
Dextrose, molecular composition of	135
Dimethyl aniline orange, use as indicator	26
Drying in hydrogen, apparatus for	100-102

E.

Ether, absolute, use of	57
time required for extraction	110
Executive committee, report on order of business	10
Experiment Station Record, publication in	151

F.

	Page.
Farrington, Mr. E. H., experiments of.....	43, 44
Fat, methods of determining.....	45
in foods and feeding stuffs.....	120
Fehling solution, use of.....	137
Fermented liquors, official methods of analysis of.....	229-231
Foods and feeding stuffs, discussion of work on.....	149, 150
reporters on.....	149
Furfuramid, occurrence of.....	126
Furfurol, estimation of.....	126

G.

German potash works, invitation to visit Washington office of.....	152, 153
Gibson, Mr. Chas. B., experiments with ammonium citrate solution.....	8, 9
paper of.....	166
Guinea pigs, exhibition of.....	182
Gunning, Mr. J. W., on determination of raffinose.....	140-142

H.

Hay, results of analyses of.....	82, 83
Huston, Mr. H. A., paper of.....	170
on analysis of cattle foods.....	90-93

I.

Iceland spar, use in standardization.....	24
Invert sugar, notes on the estimation of.....	139, 140

J.

Jenkins, Mr. E. H., discussion on report of.....	51-67
letter of.....	10

K.

Kedzie, Mr. R. C., resolution of.....	150
Kerosene oil, flashing point of.....	51
Kjeldahl flasks, kind of.....	21, 22
method, bumping in distillation.....	23
Knorr, Mr. A. E., extraction apparatus of.....	96-99
paper on calculating specific gravity.....	109
studies in specific gravity of.....	54

L.

Lactocrite, determination of fat by.....	43
Landolt, formula for specific gravity.....	54
tables of.....	197
Laurent polariscope, graduation of.....	131
Letter of transmittal.....	3
Levulose, molecular composition of.....	135
preparation of pure.....	135
Linseed meal, results of analyses of.....	84
Litmus, use as indicator.....	25, 26
Lupton, Mr. N. T., report on potash.....	68-71

M.

Manns, experiments of.....	43
Marshall Hall, excursion to.....	10

	Page.
Maxwell, Mr. Walter, methods of estimation of fat in vegetable organisms..	94
Members present, list of.....	5, 6
Methods of sugar analysis, abstracts of.....	132-148
Mohr sugar flasks	131
Myers, Mr. J. A., report of.....	148, 149

N.

National Chemical Society, report of committee on.....	182
Nitrates, analysis of, by the Kjeldahl method	12
Nitrogen analyses, averages of.....	13
by the absolute method.....	13
Kjeldahl method	12
Ruffe method	12
soda lime method.....	13
discussion of results of.....	13, 14
errors of, due to reagents.....	15
results of	11
official methods for the determination of.....	189, 195
samples, description of.....	11

O.

Officers elected.....	150
Official methods of analysis.....	189, 231

P.

Parsons method.....	43
Patented methods, exclusion of.....	65
Patents, use by chemists.....	61-63
Penny, Mr. C. L., experiments of	43
Pentaglucooses, estimation of.....	128
in feeding stuffs.....	125-128
Phenol-phthalein, use as indicator	27
Phosphoric acid, average results of analyses of	153, 159
determination of, in fertilizers containing cottonseed meal..	161-166
discussion of estimation of.....	172-181
estimation of, in the presence of silica.....	154
in beet culture	154
slags	154
official methods of analysis of	228, 229
preparation of samples for analysis	160
report on.....	153-160
results of work done on	155
reverted, difference in determination of.....	166-170
study of analysis of.....	159, 160
Platinum chloride, adulteration of.....	76
Polariscope, double-compensating, adjustment of.....	130
Polarized light, notes on	139
Politis, Mr. J. E., method of.....	136
Potash analyses, notes of analysts on.....	70, 71
results of.....	69
discussion of report on.....	73-78
in plants, division of.....	76
kinds of, samples of.....	68
preparation of samples of.....	68

	Page.
Potash salts, extent of product of mines of.....	151, 152
importance of	151, 152
Programme of meeting.....	10
Protein in foods and feeding stuffs.....	119

R.

Raffinose, determination of	140
in molasses	142
estimation of.....	137
notes on	139, 140
Rising, Mr. W. B., letter of.....	182, 183
Robinson, Mr. Norman, resolution of	151

S.

Saccharimeter, optical, standardizing of.....	129
Saccharimetry, various methods of.....	142-145
Schmidt & Haensch, letter of.....	130
Schweinitz, E. A., von, paper of.....	182
Scovell, Mr. M. A., address of	6-10
recommendations of.....	7, 8
Short's method	43
Sirups, examination of.....	147, 148
Smithsonian Institution, vote of thanks to	150
Sodium carbonate, use in standardization.....	25-28
Solvents, recovery of, from open dishes.....	102
Soldaini's method.....	136
Stations, number using association methods.....	7
Stone, Mr. W. E., paper on pentaglucooses	125
Study of foods and feeding stuffs, report of committee on.....	117
Sugar analysis, elective methods of.....	217-228
notes on methods of	129-131
official methods of.....	212-216
flasks, graduation of	129
in the beet, estimation of	138
invert, estimation of	132-133
methods of determining in milk.....	45
rapid estimation of, with one-tenth copper solution	145-147
Superphosphates, concentrated, analyses of.....	153
results of analyses of.....	156

T.

Temperature of polarization, importance of.....	133-134
Tetra-oxalate, use in standardization	24
Tobacco stems, potash in	78

V.

Vacuo, apparatus for evaporating in.....	102-105
Vegetable organisms, methods of estimation of fat in	94
Ventzke scale, value of.....	129
Voorhees, Mr. E. B., discussion of report of	17-21
recommendations of	16
report on nitrogen.....	11
suggestions of.....	17

W.

	Page.
Water, variations in boiling point of.....	56
Wheat middlings, results of analyses of.....	83
Wiley, Mr. H. W., new forms of apparatus	96
notes on methods of sugar analysis.....	129
Willits, Hon. Edwin, address of	71, 72

X.

Xylose, occurrence of.....	126
----------------------------	-----

U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF CHEMISTRY

BULLETIN

No. 29

RECORD

OF

EXPERIMENTS WITH SORGHUM

IN

1890

BY

HARVEY W. WILEY

*Chemist of the U. S. Department of Agriculture, and Director of the Department
Sugar Experiment Stations at Runnymede, Florida; Schuyler,
Nebraska; and Sterling and Medicine Lodge, Kansas.*

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON

GOVERNMENT PRINTING OFFICE

1891

Compliments of

J M Rusk

Secretary of Agriculture

U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF CHEMISTRY

BULLETIN

No. 29

RECORD

OF

EXPERIMENTS WITH SORGHUM

IN

1890

BY

HARVEY W. WILEY

*Chemist of the U. S. Department of Agriculture, and Director of the Department
Sugar Experiment Stations at Runnymede, Florida; Schuyler,
Nebraska; and Sterling and Medicine Lodge, Kansas.*

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON

GOVERNMENT PRINTING OFFICE

1891

PREFATORY NOTE.

MARCH 6, 1891.

SIR: I have the honor to submit for your approval the manuscript of Bulletin No. 29.

In this bulletin are collected such data relating to the production of sugar from sorghum as have been obtained in the experiments of the Department during the season of 1890. These experiments were conducted chiefly in the States of Kansas, Maryland, and Mississippi.

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary of Agriculture.

TABLE OF CONTENTS.

	Page.
Studies on the separation of sugar from sorghum juices	7
The composition of the bodies precipitated by alcohol from sorghum sirups ..	14
Chemical control of sorghum sugar factories.....	23
Operations at Attica, Kansas	24
Operations at Fort Scott, Kansas.....	32
Operations of the Topeka factory.....	35
Operations at Conway Springs, Kansas.....	41
Operations at Medicine Lodge, Kansas.....	44
General results of manufacturing work	50
Functions of experimental work	51
Record of work in cane improvement.....	52
Culture experiments at Medicine Lodge, Kansas.....	52
Culture experiments at Sterling, Kansas.....	54
Studies of the different varieties of sorghum	62
Work on crosses	92
Culture experiments at College Park, Maryland.....	95
Experiments at the Mississippi Agricultural Experiment Station, Starkville, Mississippi	106
Culture experiments at Fort Scott, Kansas	122

EXPERIMENTS WITH SORGHUM IN 1890.

STUDIES ON THE SEPARATION OF SUGAR FROM SORGHUM JUICES.

For many years attempts have been made by the division to secure a more perfect separation of the sugar from the non-sugars in sorghum juices. Extensive practical experiments were made in this direction at Fort Scott, Kansas, in 1886, in the practical application of the process of carbonatation.

This process consists in the addition to the mill or diffusion juices of large quantities of lime, from 1.5 per cent. to 3 per cent. of the weight of the juice, according to the amount of impurities present. The lime is then precipitated by blowing through the liquid a current of carbonic acid derived from a limekiln or coke furnace, or even from the chimneys of the boiler furnaces. The result of this process was entirely successful in respect of the yield of sugar, but on account of the blackening of the molasses, which was at that time a valuable by-product, it met with no favor from sorghum sugar manufacturers, but on the contrary was condemned by them as being unsuitable for the purpose.

Subsequently extensive laboratory experiments were made looking to the precipitation of the crystallizable sugar in the juices as sucates of lime. The process employed in the Steffen method of separating sugar from beet-root molasses was the one tried for this purpose. While these experiments were successful in separating the crystallizable sugars in the form of a precipitate, they were not wholly so in securing a separation from the non-sugars, the greater part of which were also thrown down as lime compounds or carried down mechanically with the precipitated sugar. This process was, therefore, abandoned as not being practical.

The destruction of the reducing sugars or glucoses present by boiling with excess of quicklime was next tried. This process was entirely successful in so far as destroying the glucoses was concerned, but it had no effect whatever upon the other carbohydrates, of an amorphous nature present in the juices. Inasmuch as the glucoses exert the least unfavorable influence of the non-sugars present in the juices the process was at once seen to be inapplicable from a practical point of view. The experience of the Department, and of manufactur-

ers of sugar, has shown that the reducing sugars known generally under the term of glucoses exercise a much less influence in preventing the crystallization of the sugars than was formerly supposed. In fact, it is supposed that could all other disturbing influences be removed, the glucose might not prove very objectionable in securing an almost complete crystallization of the sucrose present in the juices. It would furnish a mother liquor in which the crystallizable sugar would be highly insoluble and from which it would easily separate. Having abandoned, therefore, the methods of separation above noted, there remained to be studied some process which would separate as nearly as possible the gummy amorphous bodies from the juices without precipitating the sugar. The property of alcohol to produce precipitation in sorghum juice was made use of in the further study of this problem. On account, however, of the large amount of alcohol which would be required to treat the juices in their natural state, or as they come from the diffusion battery, it was decided to apply the process at a later period of manufacture.

In order to carry out this idea the juices of sorghum were treated precisely in the manner in which they are ordinarily in a sugar factory. The natural acidity of the juices was carefully neutralized with lime and the whole raised to the boiling point. The scums which were formed were carefully removed and the juice boiled in an open dish until all greenish scums and coagulated matters were separated.

The inversion of sugar which takes place during the boiling, which lasts only a few minutes, was not noteworthy. The juices were next concentrated in vacuo until they reached a density of 45° to 50° Brix. After cooling, the sirup thus formed was mixed with an equal volume of 95 per cent. alcohol, which was sufficient to produce a complete precipitation of the gummy amorphous matters and other bodies insoluble in alcohol of that strength. These matters were separated by passing through a filter press, forming a hard, firm cake, easily separated from the filter cloth. The filtered sirup was limpid and of an exceptionally pleasant flavor. Evaporating in vacuo after removal of the alcohol, it readily crystallized during evaporation, forming a massecuite of good grain and absolutely free from gum and capable of being treated most easily in a centrifugal.

From very poor sorghum juices from immature cane, having a purity of only 60, a most excellent article of massecuite and sugar was made by the above process.

In regard to the quantity of matters separated by alcohol, some determinations were made with the following results:

Percentage of gum secured by alcohol—

Experiment 1	2.08
Experiment 2	1.88
Mean	1.98

The juices from which these separations were made contained about 16 per cent. of solid matters; thus the percentage of matters secured by alcohol on the whole amount of solid matters present was 12.5.

It is seen from the above data that from each 100 pounds of sorghum juice about 2 pounds of melassigenic substances can be separated.

The difficulties which have been encountered in manufacturing sugar from sorghum juices have been largely due to the presence of these gums. Their removal, therefore, if it can be accomplished on a manufacturing basis, would at once place sorghum in a high rank as a sugar-producing plant.

The alcohol which is used in precipitation can be almost wholly recovered by subsequent distillation. Our experiments show that the total loss need not exceed 5 or, at most, 10 per cent. of the quantity of alcohol used. One of the most encouraging and at the same time least expected results of the work has been the demonstration of the fact that the gum separated in the manner above described is completely fermentable, yielding almost one-half its weight in alcohol. It thus appears that from the gums themselves a sufficient amount of alcohol may possibly be derived to supply the whole waste of alcohol which would take place in the process of manufacture. Any additional quantities of alcohol which might be needed could be easily obtained from the molasses after the extraction of all the crystallizable sugar. In other words, the process which has been demonstrated as thoroughly practical in the laboratory, so far as can be foreseen for the operation of an actual trial on a manufacturing scale, is capable of being conducted with economy, and a proper stock of alcohol once being provided the wastage therein in the process of manufacture could be wholly, or in part at least, supplied by the refuse matter which otherwise would be manufacturing waste.

Experiments were also made to determine the quantity of alcohol necessary to precipitate the total gum and other matters and also the strength of the alcohol required with the following result:

SORGHUM SIRUP, OF 44° BRX AT 60° F.

The quantities of ethyl and methyl alcohol required to precipitate the amorphous matters from a given volume of sorghum sirup are given in the following table:

Series of experiments.

[Comparison showing quantities of alcohol of 70, 80, and 90 per cent, and of methyl alcohol (crude) necessary for 25 cubic centimeters of sirup, of 44° Brix at 60° F.]

	70 per cent.	80 per cent.	90 per cent.	Methyl alcohol.
Chief precipitation of amorphous bodies.....	cc 20	cc 15	cc 10	cc 12
Total precipitation of those bodies.....	35	25	20	20

The portion of the amorphous bodies which is soluble in water becomes, in part, redissolved before filtration when precipitated with 70, and rather less so with 80 per cent. alcohol.

The separation of the amorphous bodies can be attained on the manufacturing scale with 80 per cent alcohol by the application of 1 volume of alcohol to 1 volume of sirup of 44° Brix.

In order to illustrate the practical application of the method on a manufacturing scale in the manufacture of sorghum sugar the following theoretical data are given :

A normal sorghum juice may contain at 18° Brix 12 per cent of sugar; a normal sorghum sirup may contain at 44° Brix 29.33 per cent of sugar, which is equal to 29,330 pounds of sugar in 10,000 gallons of sirup. Of this, 29,330 pounds (from 7,280 to 13,000 pounds), or about an average of 10,000, has been obtained by the methods of manufacture in use.

By the use of alcohol for the removal of the amorphous bodies which prevent the crystallization of the sugar, the *minimum* per cent of sugar, which, after this process would be obtained, may be put at 80 per cent (87 per cent is usually computed from pure juices), or 23,464 pounds.

10,000 pounds, at 4 cents	\$400	
23,464 pounds, at 4 cents	\$938	
Cost of alcohol.....	84	
		854
Value of product, usual method	400	
Value of product, alcohol method	854	
A gain of		454

In this estimate the material from which the alcohol is made is not regarded as of any value, since it otherwise would be wasted. If the molasses be used as a source of alcohol, then the item for the cost thereof must be increased. It is not expected that these purely theoretical figures can be reached in actual practice; but they show that a largely increased yield over that of the ordinary method may certainly be obtained. It appears, in fact, that for each ton of sorghum cane entering into manufacture, about 20 pounds of precipitate by alcohol may be obtained. This precipitate is of the highest melassigenic nature. Its removal certainly will secure an increase in the yield of sugar of from two to three times its weight, *i. e.*, of from 40 to 60 pounds. It is believed that not more than 2 or 3 gallons of alcohol will be lost for each ton of cane worked, and this would still leave a profit of fully \$1 per ton greater than could be obtained by the methods now in use. Even so small a profit as this would help to place the sorghum-sugar industry on a sound financial basis.

On account of the ease with which a heavy sirup can be preserved it has also been thought possible that during the manufacturing season the whole apparatus of the factory could be directed to making sirup alone which could be preserved and worked into sugar subsequently.

Inasmuch as it is highly important, in working a sorghum crop, to have it taken off in as short a time as possible, any scheme which will tend to simplify the operation during the harvesting season is worthy of consideration.

It is true that the storage of a whole crop of sirup would require considerable room and the cost of tanks or cellars in which it is to be held would be an item which could not be neglected. However, it must not be forgotten that by the storage system the machinery of the factory could be operated during a much longer period. For instance, it is well known that the harvesting operations and the manufacture of sugar must be chiefly conducted during the months of September and October. The manufacture of sirup into sugar, however, could be continued through the winter months, or if they were found too cold, the work could be safely left until the beginning of spring, when the factory could be again set in operation.

The whole of the apparatus for manufacturing the alcohol and for treating the sirup therewith could, therefore, be built on a much smaller scale than if it were necessary to treat the sirup as soon as it was manufactured during the months of September and October. With the sirup already made and stored in cisterns, a very small force would be sufficient to convert the whole of it into sugar and at a very small expense. It would thus be possible for one factory to take care of a much larger crop of cane than it could possibly do were the whole of the manufacturing operations to be conducted at once.

The sirup as made and as it passes into cisterns could be subjected to the influence of sulphurous acid or some other anti-ferment which would be sufficient to preserve it perfectly from fermentation, even if there were danger of such a decomposition without any antiseptic treatment.

The storage capacity of a factory which would work 20,000 tons of sorghum cane will be seen from a perusal of the following data: Assuming 20,000 tons chips and 10 per cent marc we have, 11,782,030 pounds sirup at 55° Brix, raised from 18° Brix=volume of 149,938 cubic feet, requiring a cistern 20 by 86.5 by 86.5 feet. At 75° Brix=8,640,380 pounds=volume of 100,213 cubic feet, requiring a cistern 20 by 75 by 75 feet.

In the event of boiling from 55° to 75° Brix, the water evaporated will be, on 20,000 tons of cane chips, 3,141,650 pounds, or 377,150 gallons. Basing calculations on Yaryan's figures, the coal consumption (at 8½ pounds water per pound coal) in again evaporating from 55° to 75° Brix will be 369,600 pounds, using live steam altogether, as would be necessary in the contemplated division of the season. Hence the loss occasioned by boiling to 75° Brix as a means of preserving and subsequent dilution would be $133,261 + 369,600 = 502,861 \div 2,240 = 225$ tons, plus incidental losses, radiation, time, etc.

Placing the value of coal at \$4 per ton, which is rather a high average,

it is seen that the total additional expense, so far as fuel is concerned, involved in manufacturing the sugar after the harvesting of the crop, would be only about \$900 a year, a very insignificant item when compared with the value of the time gained.

EXPERIMENTS WITH MOLASSES.

Trials of molasses from the Parkinson Sugar Company, of Fort Scott, Kansas, have also been made. In treating molasses by the alcohol method the most discouraging fact presented is that the total precipitate obtained does not bear the ratio to that obtained from the fresh sirups which would be indicated by their respective degrees of concentration. If a fresh sirup should yield a precipitate which is approximately 2 per cent of the weight of the normal juice, the molasses *a priori* would give similar results. Instead of this, however, the weight of the precipitate obtained from the molasses was in every case much less than was theoretically expected. It was anticipated that the molasses would yield a precipitate corresponding to from 6 to 8 per cent of its weight. There was really obtained only about half this quantity. This would seem to indicate that the amorphous bodies had undergone some hydrolytic fission during long-continued boiling and standing in tanks, and that the resulting bodies were more soluble in alcohol than were the originals. These experiments indicate that even the storage of sirups, as indicated above, might be attended with serious results threatening the success of the process. Further experiment is therefore necessary to determine the practicability of the processes proposed.

COMPOSITION OF THE MOLASSES AS AFFECTED BY TREATMENT WITH ALCOHOL.

Two samples of sorghum molasses resulting from the manufacture of first sugars at Fort Scott in 1890 were submitted separately to analysis and alcohol treatment. The results follow :

	Before treatment.		After treatment.	
	First sample.	Second sample.	First sample.	Second sample.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Ash	5.30	5.19	4.99	2.84
Water	21.00	24.54	19.26	17.90
Glucose	21.70	19.44	22.69	23.09
Sucrose	42.30	43.61	48.96	51.62
Undetermined	5.90	3.53	3.78	4.55
Alcohol precipitate	3.80	3.69	.....	.....
Purity	53.55	57.79	60.64	62.88

The increase in the purity coefficient in both samples after treatment with alcohol is very gratifying.

The resulting sirups from both samples were placed together in a warm room and yielded a large crop of crystals, but the pounds of sugar thus obtained per gallon of molasses used could not be directly deter-

mined. The general result of the experiments shows that the proper time for the application of the alcohol is to the sirup of about 50° Brix as soon as it is prepared.

If, however, it be found impracticable to treat the whole crop as it is manufactured by this method, it may prove economical to store a part of it as has already been indicated, or to manufacture a part of it by the processes now in use, leaving the molasses for subsequent treatment.

In order that this method of production of sugar may become possible, it will be necessary for the revenue laws to be changed so as to allow the preparation of the alcohol used in the process to be carried on without tax. This could be easily done without any danger of defrauding the revenue. The alcohol could be made under bond, given by the sugar manufacturer, that it should be used only for the purpose of separating the gummy matters from the sorghum juice, and should in no case enter commerce for any purpose whatever. In making this alcohol the manufacturer should be allowed to erect such apparatus as may be necessary, and this apparatus could be under the direct inspection of revenue officers in order that they might be able to see that the conditions of bond were faithfully carried out.

It is earnestly recommended that the revenue laws be so amended as to allow a trial of this process by the sorghum-sugar makers of the country. If this can not be done without a further illustration, the law, at least, should be so adjusted as to permit the Department to make an experiment on a small scale with this method in connection with the work which it is now doing in the experimental station for the improvement of sorghum cane and the manufacture of sugar therefrom.*

It is important also that the Department be empowered, by a special grant, to carry out these experiments in a practical way. From the best estimates which are now at my disposal I should say that a grant of \$25,000 would be entirely sufficient to subject this process to an experimental trial. The magnitude of the interest involved is so great that it is hoped that no objection will be made to this experiment.

Not only is the increase in the output of sugar from sorghum cane to be taken into consideration, but also the improvement in the quality of the product. The sugar will be of a finer grade and much more easily separated from the molasses. The molasses instead of being, as it is now, a waste product scarcely marketable, and in many cases only fit for cattle food, will be suitable for table use and especially for mixing, in case compound sirups are desired. The flavor of both the sugar and the molasses produced is of the finest quality and of such a nature as to render it difficult to believe that it could have been made from sorghum, which, under ordinary circumstances, affords a molasses which is unpalatable.

* These recommendations were favorably considered by Congress and the permission to use alcohol in bond was granted.

This process having been outlined above in such a way as to indicate its true character, it is hoped it may be given to the sugar manufacturers of the country without interference from any patents which may attempt to secure its provisions for private benefit. As our patent laws now stand any process which has not been in use for two years may be covered by letters patent, but in this case it must be distinctly proved that the inventor is, as he claims in his application, the true discoverer of the process. This process having been discovered and operated by the Chemical Division of this Department, is unpatentable, except by the Department for the common use of the people.

THE COMPOSITION OF THE BODIES PRECIPITATED BY ALCOHOL FROM SORGHUM SIRUPS.

The data following were obtained by an investigation undertaken with the collaboration of Mr. Walter Maxwell, who had charge of the laboratory work.

It has often been a matter of surprise that sorghum juices with a promising polarization yielded quantities of sugar sadly disappointing. Since the work of the Department relating to sugar production was for many years, in accordance with the acts of Congress, devoted wholly to experiments relating to sugar manufacture, it was not found possible to make a thorough study of the character and constitution of the various melassigenes which were supposed to be present. For the past two years, however, the work of the Department, and of the chemical division in particular, has been more and more directed to the agricultural and chemical properties of the sorghum plant in all stages of its growth, beginning with the seed and ending with the natural plant. Portions of the work have already been published in a paper by a member of the division in the *Proceedings of the Society for the Promotion of Agricultural Science* for 1889, and in a joint paper published in the *American Chemical Journal*, Vol. 12, No. 3. The following contribution contains the results of the preliminary investigations of the mucilaginous and carbohydrate melassigenes, in which it is believed that each important one has been separated and wholly or in part identified. When the great number of these amorphous and dis-morphous bodies is considered, and the aggregate large percentage of sorghum melada which they form is taken into consideration, it is no longer a matter of surprise that the yield of sorghum sugar is so small, but rather so large.

The purely chemical problems involved are even of greater interest than the economic ones, and it is to these that the present paper is devoted.

The question of the total optical effect which these various bodies

exert on the ray of polarized light is reserved for a more intimate future study. Some of these bodies are undoubtedly levogyres, such as the nitrogenous compounds, while among the dextrogyres are to be reckoned most of the carbohydrate compounds which have been separated. We are, therefore, at the present time, unable to say that the direct, or even indirect, polariscopic reading of a sorghum juice correctly indicates the true content of sucrose therein.

The subject of the non-crystallizable matters present in sorghum molasses was taken up by Dr. Collier and C. Richardson, and the results of their investigation are given in the Report of the Commissioner of Agriculture for 1878, page 107. Those results appear to be as follows :

The gum was precipitated out of the water solution of the molasses with 95 per cent. alcohol. The gum was washed with alcohol, and, after evaporating off the alcohol, was dissolved in a little water and purified with boneblack. The solution with alcohol gave a snow-white precipitate, which, after washing with alcohol and ether, could not be dried over sulphuric acid without drying up into a black, oxidized mass. "The gum so prepared is a white powder, easily oxidizing on exposure to the air and turning black. It is somewhat deliquescent. Under 80 per cent. alcohol it may be preserved indefinitely as a snow-white substance." It was further observed that the body, which was soluble in water, gave many of the reactions characteristic of mucilages; but "with Fehling's solution it gave a floccy precipitate, reducing only slightly," which latter was "probably owing to a trace of sugar in the gum."

The method pursued in the present investigations of the sorghum gummy, mucilaginous and other amorphous bodies, was as follows :

A large volume of the molasses was dissolved in the same volume of water and placed in large precipitating jars. To the water solution was added an alcohol of from 98 to 99 per cent., and until the precipitation of matters was no longer observed. The total precipitate, which could contain nitrogenous and non-nitrogenous bodies, was of great volume, and had a dark gray, mucilaginous appearance. After standing some hours, the bulk of the liquid was removed with a siphon, and the precipitate separated from the remaining liquid by filtering through cloth. The total precipitate was placed in a large jar and saturated with strong alcohol, standing 2 days. The precipitate was again separated by filtering, washed out with alcohol, and placed on the steam bath at as low a temperature as the alcohol would evaporate.

The *original precipitate*, obtained by the process that has been described, was examined in the following way :

In order that the solvents could act as quickly as possible upon the precipitate, it was divided into portions, and saturated with a large volume of water, first in the cold and afterwards at a temperature of about 65° C.

The precipitate, or total matters, was suspended in water, and fre-

quently stirred, for as many hours as it was sure that no change could be caused by the water in the nitrogenous matters. The bodies soluble in water were separated by filtering and the residue of the original precipitate washed out with water.

FERMENTATION OF THE CRUDE PRECIPITATE.

The carbohydrate bodies contained in the crude precipitate appear to be completely fermentable. From 420 grammes of the water free material there were obtained 164 grammes of absolute alcohol. Previous hydrolysis of the carbohydrate bodies does not appear to increase the yield of alcohol.

From 450 grammes of the crude material boiled for 3 hours with 1 per cent. H_2SO_4 there were obtained only 152 grammes of absolute alcohol. The purified gums soluble in water yield a full theoretical quantity of alcohol without previous hydrolysis.

OCCURRENCE OF PENTAGLUCOSE.

The alcohol precipitate, tested by the method of Stone, yielded considerable quantities of furfurol, indicating the presence of a pentaglucose.

It was stated in the work already referred to, and contained in the Report of the Commissioner of Agriculture for 1878, that the original precipitate was soluble "in a little water." In the present investigation it was found that only a part of the original precipitate was soluble in water after saturation for several hours, and that one-third remained as an undissolved residue. From a physiological view such a result was to be expected. In consequence of the observation concerning the solubility in water, it was resolved to study the total matters contained in the original precipitate according to the order of their solubilities, and in the sequence expressing—

1. The series soluble in water.
2. The series soluble in sulphuric acid (dilute).
3. The series soluble in sodic hydrate (dilute).
4. The series soluble in cuprammonium.

1. *Bodies soluble in water.*—In the preliminary investigation it was seen that only about two-thirds of the original precipitate was soluble in water. The "water soluble part," after filtering and washing out of the insoluble residue, was treated with bone-black, which made the brown-colored solution a bright yellow, and condensed to a small volume. After cooling, alcohol of 99 per cent concentration was added to the solution until the precipitable matters were totally thrown out. The precipitate was brought upon a filter and washed out with strong alcohol, when it was white in appearance in comparison with the "original precipitate." In order, however, to obtain the body, or mixture of bodies, free from coloring and mineral matters, the precipitate was re-

dissolved in water, and re-precipitated with alcohol six times, and, after the final filtration, pressed between filter paper to remove the excess of moisture and afterwards dried over H_2SO_4 in a desiccator, by which process an almost pure white, amorphous body, or mixture of bodies, was obtained.

In proceeding to examine the properties of the portion of the original precipitate soluble in water certain indications are observable in the chemical behavior with the following reagents :

- | | |
|---------------------------|----------------------------|
| 1. Neutral or acid iodine | = purple coloration. |
| 2. Basic plumbic acetate | = white precipitate. |
| 3. Sodid acetate | = no action. |
| 4. Magnesian sulphate | = slight turbidity. |
| 5. Sodid sulphate | = no action. |
| 6. Ammoniac sulphate | = no action. |
| 7. Sodium phosphate | = heavy white precipitate. |
| 8. Ammoniac phosphate | = heavy white precipitate. |
| 9. Phosphotungstic acid | = heavy white precipitate. |
| 10. Fehlings' solution : | |
| Before hydration | = no action. |
| After hydration | = strong reduction. |

The sensibility of the body to the color action of iodine may indicate the presence of a modification of starch, or of a mucilage ; that property, however, does not show which of the two is present, but rather that both may be.

The lead acetate, as was observed, threw down out of the aqueous solution a heavy white precipitate, which could include the mucilaginous, albuminous, and other matters. After the precipitation with lead acetate and the removal of the excess of lead from the filtrate, the latter, on being concentrated, gave a further precipitate with a strong alcohol, indicating that, in addition to the mucilaginous matters separable by lead acetate, one or more of certain amorphous carbohydrates may be present, which bodies, although insensible to lead acetate in aqueous solution (excepting in instances where carbohydrates may be in combination with a gum or mucilage), are precipitated by strong alcohol.

The greater part of the bodies, however, is separated out of the aqueous solution with lead acetate, indicating that a mucilage or gum or several modifications of such bodies compose the chief weight of the portion of the original precipitate which is soluble in water.

The aqueous solution of the bodies was studied in its behavior with solutions of the neutral sulphate and phosphate salts already specified, and in the light thrown upon the subject by the researches of Dr. Julius Pohl (See *Zeitschrift für physiologische Chemie*). It has already been observed that the aqueous solution gave no precipitates with solutions of Na , NH_4 , and Mg sulphates, excepting the latter, when a turbidity was seen. With solutions of Na and NH_4 phosphates heavy and stable precipitates were obtained. It has been found by Dr. Pohl that the tragacanth, althea, linseed, and cydonia mucilages are precipitated by saturating their aqueous solutions with sulphate of ammonia. The

aqueous solution of the present body is wholly insensible to NH_4 and Na sulphates, consequently it has no identity with the above-cited mucilages. Carrageen and salep mucilages are precipitated out of aqueous solution by both the sulphate and phosphate of ammonia. The present body, whilst precipitated by NH_4 phosphate, is wholly indifferent to NH_4 sulphate. It thus appears that the mucilage or gum body under consideration indicates some approach to the carrageen and salep mucilages in its action with phosphate salts, but it is distinguished from the known mucilages in its behavior with the neutral sulphates. It was observed that Mg sulphate gave a turbidity when added to the solution of the body; that salt, under some conditions, will precipitate soluble starch, galactins, dextrins, etc. In a treatment of the water soluble matters, separated from the juices of the sorghum cane, with Mg sulphate an amorphous white body was obtained whose properties have not been further examined for want of material. It is possible that the turbidity caused by the Mg sulphate may have been due to some small portion of the body observed, in another place, in cane juices having remained unchanged in the molasses made from the cane. It thus appears that the main part of the bodies separated from the original precipitate in aqueous solution is composed of a mucilage or gum having a characteristic agreement with other known mucilages by its sensibility to iodine and to boiling with dilute neutral acids, after which latter treatment its products reduce an alkali-copper solution. It is, on the other hand, distinguished from other mucilages by its insensibility to saturated solutions of neutral sulphate salts.

It was likewise observed that the aqueous solution of the bodies gave a heavy white precipitate with phosphotungstic acid. That reagent would remove from the solution the mucilaginous matters thrown out by the Pb acetate and also any alkaloidal principles if present. After treatment of a portion of the aqueous solution with phosphotungstic acid, and neutralizing the filtrate with barium, the filtrate had no action on Fehlings' solution; but after boiling the solution with hydrochloric acid it reduced the copper solution abundantly. The action of dilute acids upon the mucilages produces sugars capable of reducing copper solutions; in this case the mucilage bodies were previously removed by the phosphotungstic acid, consequently the body or bodies remaining in the solution, which, after inversion, acted upon the Fehlings' solution, are amorphous carbohydrates, which bodies, after the previous separation of the mucilaginous and other matters by Pb acetate, have already been stated to be thrown out of solution with strong alcohol.

It was considered of interest also to study the optical disturbances produced in a solution of sorghum molasses by the successive removal of the nitrogenous bases and the residual substances insoluble in alcohol.

For this purpose a quantity of molasses was diluted with an equal bulk of water and treated with basic subacetate of lead in slight excess.

The excess of lead was removed by the cautious addition of dilute H_2SO_4 until no further precipitation took place. Only a trace of acid being used in excess it was not found necessary to remove it with barium carbonate. The total volume of 100 cubic centimetres of the first filtrate after this treatment was found to be 106.1 cubic centimetres. The polarization, in sugar degrees, of this solution was $64^\circ.99$; 20 cubic centimetres of the above liquor were treated with phosphotungstic acid until no further precipitation took place and the volume was made up to 50 cubic centimetres. This solution polarized $25^\circ.40$, which, calculated to original volume, equals $67^\circ.37$. Twenty-five cubic centimetres of the phosphotungstic filtrate were made up to 50 cubic centimetres with 96 per cent alcohol and filtered.

The filtrate polarized.....	$13^\circ.60$
Or on original substance.....	$72^\circ.15$

The several polarizations of the different liquors, calculated to the original solutions, are given together below :

Solution clarified by lead	$64^\circ.99$
After treatment with $\text{H}_{11}\text{PW}_{10}\text{O}_{38}$	$67^\circ.37$
After treatment with $\text{H}_{11}\text{PW}_{10}\text{O}_{38}$ and alcohol.....	$72^\circ.15$

The experiments were repeated on a somewhat more concentrated solution of molasses, and the summary of results is as follows :

	Polarization.
After treatment with lead	$83^\circ.92$
After treatment with lead and $\text{H}_{11}\text{PW}_{10}\text{O}_{38}$	$84^\circ.54$
After treatment with lead, PW_{10} , and alcohol.....	$87^\circ.93$

The results clearly indicate that the removal by phosphotungstic acid of the nitrogenous rest frees the solution from a levogyrous body.

The marked increase in dextrogyrous power shown on the treatment of the solution with alcohol however is doubtless due in part to the depressing effect of alcohol on the rotatory power of the levulose present. The body, precipitated by alcohol, is in appearance dextrinoid, and the logical supposition would be that the dextrogyrous property of the solution would be diminished, which in fact is not the case. The notable depression of rotatory power produced in levulose solutions by alcohol has been mentioned by Herzfeld (Berichte 19, 398).

Character of the alcohol precipitate.—The precipitate obtained by alcohol in the above experiments is undoubtedly of the same composition as that of the dysmorphous carbohydrates obtained by the method of separation at first followed. It is, however, thus obtained directly after the removal of all the organic acids and mucilaginous bodies or gums. Purified by reprecipitation and dried at ordinary temperatures over H_2SO_4 in vacuo, it was found difficultly soluble in water and doubtless consists of two bodies differing in their solubilities in water.

A little over half a gramme of it (0.5316 gramme) gave in 25 cubic

centimetres in a 600-millimetre tube an angular rotation of $3^{\circ}.38 = 1^{\circ}.13$ for a 200-millimetre tube, or $0^{\circ}.283$ for 0.5316 grammes in 100 cubic centimetres. Then

$$(a)_D = \frac{100 \times 0.283}{2 \times 0.5316} = 26^{\circ}.6.$$

This body is, therefore, not any of the ordinarily occurring sugars, but is probably composed of an optically inactive body with a small proportion of a dextrinoid or a dextrogyrous body resembling quercite in optical properties. It was without action on alkaline copper, but after hydration with H_2SO_4 was strongly reductive.

The conclusion is thus indicated that that portion of the original precipitate which was soluble in water is composed of a mucilage having the characteristic properties given, and of a carbohydrate or carbohydrates, which are without action upon the alkali-copper solution before boiling with an acid, and which, after inversion, are strongly reducing bodies. These carbohydrates have yet to be identified. They have only a slight action on polarized light. Their classification is reserved for subsequent work.

Bodies soluble in dilute sulphuric acid.—After the separation of the bodies soluble in water the residue of the original precipitate was submitted to the action of dilute sulphuric acid. The residue was heated upon the steam bath with a 1.5 per cent. acid for a period of 10 hours at a temperature of $85^{\circ} C$. After filtering the still undissolved residue was washed out and the washings added to the solution. The H_2SO_4 solution was neutralized with $BaCO_3$ and evaporated to a sirup. The sirup was extracted with 95 per cent. and 85 per cent. alcohols consecutively. A part of the sirup was taken up by the alcohol; a large part, however, was coagulated and remained behind after extracting for 2 hours under a condenser. In consequence of the behavior of the sirup with alcohol the portion of the original precipitate soluble in dilute H_2SO_4 must be considered in two parts:

(a) Part of sirup soluble in alcohol; (b) part of sirup coagulated by alcohol.

(a) The part taken up by alcohol was evaporated to drive off the alcohol and the residue taken up in water and treated with boneblack. The water solution was concentrated, brought into a stoppered bottle and five volumes of strong alcohol added, and the bottle placed in a freezing mixture of ice and salt. After repeated renewals of freezing the liquid became quite clear. A heavy sirup, having the appearance of uncrystallized sugar, precipitated to the bottom of the bottle, and a crystallized body, much resembling dextrose in appearance, separated out. After pouring off the alcohol the crystallized body was separated from the sirup or sugar-like body. The crystal lized body was readily soluble in water. It was without effect upon the ray of polarized light, consequently it was not dextrose. It is reserved for further examination.

The sirup or sugar-like body was most soluble in water and reduced Fehling's solution powerfully, and had a levorotatory action upon the ray of polarized light, but to only a small specific degree. After standing some days in a desiccator a symptom of crude crystallization occurred in the form of warty aggregates, which, however, were still saturated with the sirup. When a few of the aggregates were separated from the sirup and their aqueous solution repolarized the levorotatory action had become almost totally neutralized, indicating that the sirup is composed of parts of dextrose and levulose, and in such proportions as mutually neutralize their opposite actions on the polarized ray. The water solution of those mixed sugars gave a phenyl-hydrazine compound with the characteristics of the dextrose compound. The further study and identification of those sugars which are the decomposition and hydration products of a portion of the original precipitate soluble in dilute H_2SO_4 are reserved.

(b) The part of the sirup which has been described as being coagulated by alcohol was soluble for the most part in water. To the aqueous solution was added 1.5 per cent. H_2SO_4 and the flask set aside for 4 days. During the 4 days that the solution was standing a crystallized body separated out in clusters of fine silky needles. The crystallized body was soluble in water, but not readily. With H_2SO_4 no reaction occurred. With BaCl_2 a heavy precipitate of BaSO_4 was given, indicating that the crystallized body was an organic sulphate compound.

After separation of the crystallized body spoken of, the solution was boiled for 4 hours, neutralized, and evaporated to a sirup. The sirup was taken up in water, treated with boneblack, and afterwards concentrated to a small volume and brought into a bottle with 5 volumes of alcohol and placed in the freezer. A large amount of amorphous body separated out which was soluble in water, gave no reaction with iodine, nor with phosphotungstic acid, but was precipitated with Pb acetate. The body is reserved for further examination. It thus appears that the portion of the original precipitate which was soluble in dilute H_2SO_4 is composed of bodies resembling the bodies which were found soluble in water, and differing from the latter in the manner or degree of their solubilities. A modification of, or a less soluble mucilage or gum has been observed, which by treatment with a dilute acid became broken up into copper reducing sugars and other undetermined matters. Another body gave a crystallized compound with H_2SO_4 , and a third body was found which showed an indifference to iodine and phosphotungstic acid. The precise chemical study and classification of these bodies is reserved.

Bodies soluble in dilute sodic hydrate.—The residue of the original precipitate, after the treatments already described, was further submitted to the action of dilute sodic hydrate with a concentration of 1.5 per cent. The material was saturated with a large volume of NaOH for 4 days. After separation from the residue the solution was treated

first with phosphotungstic acid, when a heavy precipitate was thrown down in very singular forms, and most resembling ants' eggs. This body was insoluble in water and in strong NaOH. When no further precipitate was obtained with phosphotungstic acid, a little concentrated hydrochloric acid was added to the filtrate from which the phosphotungstic had been separated, and a second, but smaller precipitate was obtained which behaved like a true albuminoid. Those bodies have not yet been further examined.

4. *Bodies soluble in cuprammonium*.—After the treatment with NaOH a still considerable part of the original precipitate was remaining. Upon removing the alkali the material was saturated with a solution of cuprammonium for a period of 10 days, being frequently shaken and agitated during the whole time. The solution was filtered through glass wool, and concentrated HCl added, when a voluminous precipitate was given. Upon adding the HCl until the solution was slightly acid a large part of the precipitate became redissolved. The undissolved part of the precipitate thrown down with the HCl was separated by filtering and behaved completely as true cellulose. The other part resembling the true cellulose in so far that it was insoluble in the solvents used previous to cuprammonium, was distinguished from cellulose by its ready solubility in a slight excess of HCl. The filtrate in which the latter body was precipitated out of the solution with strong alcohol and also with NaOH and partly with phosphotungstic acid, indicating that it could be a mixture of mucilaginous and carbohydrate bodies or matters.

The last portion of the original precipitate which resisted the action of the solvents preceding the use of cuprammonium exhibited a similar mixture or combination of mucilaginous and carbohydrate bodies found in the portions soluble in water and H_2SO_4 , and appearing to differ mainly in the degree of solubility. By the cuprammonium was discovered and obtained a preparation of true cellulose, which appears to have been in combination with the other body which was separated from the cellulose as already described. It is possible that the latter body may be a carbohydrate which is soluble in an excess of acid which would not affect the cellulose. However, the combination of the cellulose with a gum or mucilage body is strongly indicated.

In recapitulating the results of this preliminary study of the amorphous matters contained in the sorghum molasses, and which prevent the separation of the crystallizable bodies, it has been found that those amorphous matters are composed of nitrogenous mucilaginous and carbohydrate bodies. It has further been observed that each class of those bodies is represented by several modifications which are distinguished mainly by their differing degrees of solubilities: that is, that there are mucilaginous and carbohydrate bodies which are distinguished from each other by the instance that certain are soluble in water, others in

dilute acids, dilute alkalis, and cuprammonium respectively, which confirms the physiological supposition upon which the preliminary study of those amorphous matters was based and commenced, viz, that the whole of such were not probably to be found soluble in water.

Not only have mucilages and carbohydrates been observed during the course of these studies in the sorghum molasses; certain nitrogenous bodies have been found. A general view of the organic series of bodies (other than sugars) in the molasses may be gained by means of consecutive fractional precipitations with the following reagents: By addition of Pb acetate to an aqueous solution of the molasses, the chief part of the mucilaginous and certain carbohydrate matters with organic acids, etc., are thrown out. Upon removing the excess of lead from the filtrate other amorphous carbohydrates are removable with strong alcohol. And, finally, after removing by evaporation the alcohol from the filtrate and taking up the residue in water and purifying with bone black, by adding phosphotungstic acid an alkaloidal principle may be found. Such a body has been obtained by a different method and in a crystallized form as a double salt of chloride of platinum, of which a specific study has not yet been made.

The investigations will be continued in order to identify definitely certain of the mucilaginous and carbohydrate bodies of which only preliminary observations have been obtained. By such means it may be possible to further unfold the relations of those bodies represented and accompanying each other in the several modifications and degrees of solubility which have been observed, and also to work out a path to the better understanding of such as the pectinous bodies which have been thought to be mucilaginous and carbohydrate compounds.

The principle upon which the investigations have been conducted has so far been physiological-chemical, and especially having in view the nature of the total and respective bodies found in the molasses as indicated by their order of solubilities.

Having established methods by which the total original precipitate can be separated into several classes of bodies, each class of bodies and body is to be studied separately, in order to ascertain their chemical nature as indicated by the decomposition products and other chemical behavior.

CHEMICAL CONTROL OF SORGHUM SUGAR FACTORIES.

The Department made no direct experiments during the season of 1890 in the manufacture of sorghum sugar. The work done was confined solely to chemical supervision of the processes of manufacture. To secure as wide an experience as possible in this direction, chemists were detailed from the Department for the factories at Fort Scott, Topeka, Conway Springs, Attica, and Medicine Lodge, Kansas. A sum-

mary of the chemical work done, together with such data as were accessible, will be found following :

OPERATIONS AT ATTICA, KANSAS.

The chemical work at Attica was in charge of Mr. J. L. Fuelling, assisted by Mr. J. R. Cooper.

Work at this station was started on the 19th of September and continued, at intervals, until October 25. On this latter date one of the lower doors of the diffusion battery cell was broken and it was not thought worth while to repair the battery for the remaining portion of the crop. A very small quantity of cane remained unworked. The many difficulties encountered in the working of this house would render it unjust to make the results a test of the possibilities of manufacture of sorghum sugar.

The cane crop was much shortened by a severe drought, which set in about a month after the planting and continued unbroken for 60 days. The yield of cane per acre was reduced from 12 to 15 tons of last year to 5 and even 3 tons per acre. Chinch-bugs were also quite numerous and did considerable damage. Hot winds, the most dreaded enemy of the farmer in that region, were prevalent during the continuation of the drought. Not only was the crop shortened by the continued dry weather, but also the supply of water for the factory was inadequate, the small stream upon which dependence was placed having been completely dried up. Under these conditions the factory was not operated continuously, but only during the day.

The necessity of better cultivation of the cane fields was fully manifested in a number of instances. The fields which received poor cultivation were almost devoid of crops, while those which received the best cultivation yielded a fair crop in spite of the hot and dry weather. It was not until October 12 that there were sufficient rains to insure an ample supply of water, but at that time it was not possible to get enough cane to operate the factory.

The seed which had been received from the Department of Agriculture produced, in all cases, the best cane grown in the locality, averaging 4 and 5 tons per acre above all other varieties. The loss of a large quantity of sugar in the battery was owing to the heaters which leaked very badly. Another serious loss occurred between the clarifiers and double effects. This was due to the inability of the double effects to evaporate the juice extracted so that some of the thin juice was left sometimes as long as 12 hours before being concentrated, and, of course, fermentation took place.

Special attention was given to studying the characteristics of the cane, showing that certain physical properties are associated with high percentages of sugar. By studying these properties carefully, it is possible for every farmer to go into his field and be able to determine certainly whether his cane is ripe or not. The most striking of those prop-

erties is found in the last joint of the cane bearing the seed head. By stripping the cane of its covering a yellow coloration will be observed extending more or less along the length of the joint as the cane nears maturity. By the extent of this coloration one is able to select the very best or the very poorest canes in the field almost as accurately as though tested by a polariscope. It is found that the cane which has the highest sucrose, lowest glucose, and highest purity has this coloration extending one-half the length of the joint. Should it be found to extend the full length, it shows that the cane has already commenced to deteriorate. On the other hand, should no coloration be visible, it shows that the cane is not yet mature. These observations have extended over one season of rather remarkable characteristics, and hence they may not prove equally applicable to a crop grown in a season with the ordinary amount of rainfall.

The analyses of the sorghum at Attica were commenced on the 9th of September and continued until the 24th of October. During this period 115 average samples, as taken from the field, were analyzed with the following mean results :

In the juice.

Per cent. sucrose.....	14.26
Per cent. reducing sugars or glucose	1.53
Purity coefficient.....	71.91
Maximum per cent. sucrose.....	17.95
Minimum per cent. sucrose.....	5.85
Maximum per cent. reducing sugars or glucose.....	3.43
Minimum per cent. reducing sugars or glucose.....	.55
Maximum purity of juice	90.80
Minimum purity of juice	35.83

Between the dates of October 6 and 9 the purities of the juices were remarkably high, averaging about 85, and the percentages of sucrose therein were almost 16, showing that at that season the cane was in the best condition for manufacture. The analyses, however, for the whole season show a cane well suited for the manufacture of sugar, and which should yield, if all the sugar could be obtained, except the quantity which would naturally stay in the molasses, quite 200 pounds to the ton of clean cane.

Many of the farmers found the growing of cane profitable, while in other cases quite a number failed to make any profit or cultivated the cane at a loss. The figures representing one farmer's account with the company will illustrate what may be secured in a poor season in the growing of sorghum cane.

Total weight of cane grown.....pounds..	357,735
Total weight of seed grown.....do.....	74,915
Amount received for the cane.....	\$357.74
Amount received for the seed.....	\$35.18
Total receipts for the crop.....	\$392.92

Against this sum the following expenses are to be charged:

Cost of planting.....	\$37.50
Cost of cultivating.....	50.00
Cost of harvesting and delivering to mill.....	175.00
Total cost, as charged.....	262.50

Leaving a net profit of \$130.42. The number of acres cultivated in this crop was 30, and on the number given above the profit per acre would be \$4.35. It will be noticed in the above that no charge has been made for the rent of the land, which is, of course, a legitimate expense which must come out of the calculated profit per acre. The rental of the land upon which this cane was grown is not known to me, but, judging from the average value of land in that locality, it may safely be put at \$2 to \$2.50; hence a deduction of \$2 per acre should be made for rent of land, leaving a profit per acre of only \$2.35 instead of \$4.35.

The analyses of the samples of chips taken from the shredders as they pass to enter the battery, which samples give a fair estimate of the quality of the chips entering the diffusers, show, as is usual in all cases, a less saccharine strength than average samples of field cane. The reason of this difference is twofold. In the first place the samples of the first chips must of necessity give a better representation of the crop than any possible selection of single stalks or number of stalks of cane can give. In the second place, in spite of the best clarifying apparatus, particles of the blades and sheaths enter the shredder with the pieces of cane, and the juices of these are expressed afterward and mingle with the juices of the cane. Forty samples of these chips were analyzed during the season with the following mean results:

In the juice.

Sucrose.....	per cent..	12.56
Glucose.....	do.....	1.99
Purity.....		63.20

Thirty-two samples of the diffusion juices, representing the mean composition of the juices during the season, were subjected to analysis with the following mean results:

Sucrose.....	per cent..	7.99
Glucose.....	do.....	1.20
Purity.....		66.48

Thirty-two samples of the exhausted chips, representing the mean composition of the whole mass of exhausted chips during the season, were analyzed, the analyses showing that they contained 0.60 per cent. of sucrose.

Twenty analyses of the filtered and clarified juices, representing the mean composition of the clarified juices of the whole season, showed the following average constitution:

Sucrose.....	per cent..	8.11
Glucose.....	do.....	1.01
Purity.....		67.46

Seventeen analyses of the sirups before entering the strike pan, representing the average composition of the whole sirup worked during the season, gave the following mean results :

Sucrose	per cent..	32.91
Glucose	do....	7.12
Purity		63.11

Eight analyses of the massecuites, representing the average composition of the whole mass produced during the season, gave the following mean results :

Sucrose	per cent..	54.89
Glucose	do....	12.32
Purity		62.35

Five analyses of the second masse cuites, boiled from the first molasses after the separation of the first mass of crystals, showed the following mean composition :

Sucrose	per cent..	47.52
Glucose	do....	12.77
Purity		55.65

The total amount of field cane purchased during the season was 1,305.3 tons. After cleaning, the total weight of cane which entered the diffusion battery was 900.2 tons.

The theoretical percentage of sugar in the clean cane, as calculated from the juice of the chips, was 238.6 pounds.

The quantity of sugar obtained in a merchantable form can not be accurately known until the official report of the State sugar C. innspector is known. The quantity, however, in proportion to the total amount present was extremely small and probably did not exceed 75 or 80 pounds per ton.

The enormous losses, therefore, in manufacturing sorghum sugar, which have always been noticed in practice, are illustrated in a very emphatic manner by the results of the season's work at Attica. Such losses are due to the natural wastage during the process of manufacture, and are, of course, raised to an unusual degree where lack of skill exists in the manipulation of the factory. The chief losses, however, as heretofore, have been due to the character of the juice itself, presenting in its constitution peculiar difficulties in the separation of the crystallizable sugar present.

Following are the summaries of the analytical data obtained :

Analyses of sorghum cane, Attica, Kansas, 1890.—Samples represent field averages.

No.	Date.	Su- crose.	Gluc- cose.	Purity.	Variety of cane.	No.	Date.	Su- crose.	Gluc- cose.	Purity.	Variety of cane.
1	Sept. 9	16.70	.....	75.09	Amber.	54	Oct. 6	14.50	2.52	86.10	Orange.
2	Sept. 9	15.70	.....	77.70	Do.	55	Oct. 6	16.25	1.32	89.59	Do.
3	Sept. 9	16.40	.....	78.60	Do.	56	Oct. 6	17.20	1.09	88.78	Do.
4	Sept. 9	15.75	.....	78.04	Do.	57	Oct. 6	15.65	1.69	86.41	Do.
5	Sept. 9	16.10	.....	76.37	Do.	58	Oct. 6	15.70	1.46	80.70	Do.
6	Sept. 9	14.35	.....	74.42	Do.	59	Oct. 6	17.95	.....	90.80	Do.
7	Sept. 9	14.35	.....	78.30	Do.	60	Oct. 8	15.10	2.66	81.44	Do.
8	Sept. 9	15.50	.....	78.50	Do.	61	Oct. 8	16.70	2.58	82.22	Do.
9	Sept. 9	12.50	.....	68.14	Do.	62	Oct. 8	14.00	1.32	70.31	Do.
10	Sept. 9	16.10	.....	78.30	Do.	83	Oct. 8	12.65	1.77	70.35	Do.
11	Sept. 9	12.25	.....	73.48	Do.	84	Oct. 8	14.40	1.13	71.35	Do.
12	Sept. 10	16.10	.....	78.30	Do.	85	Oct. 8	13.60	1.22	74.71	Do.
13	Sept. 10	13.65	.....	75.70	Do.	86	Oct. 8	15.72	1.09	76.52	Do.
14	Sept. 10	15.10	.....	77.80	Do.	87	Oct. 8	14.00	1.25	74.35	Do.
15	Sept. 10	15.55	.....	75.81	Do.	88	Oct. 8	14.15	1.13	72.97	Do.
16	Sept. 10	14.60	.....	75.00	Do.	89	Oct. 8	14.85	1.74	71.79	Liberian.
17	Sept. 10	14.10	.....	73.86	Do.	90	Oct. 8	13.80	1.59	75.40	Do.
18	Sept. 10	15.05	.....	75.51	Do.	91	Oct. 8	13.05	1.44	79.63	Orange.
19	Sept. 10	15.55	.....	77.77	Do.	92	Oct. 8	13.15	1.17	71.15	Do.
20	Sept. 10	14.32	.....	75.42	Do.	93	Oct. 18	14.00	1.17	73.90	Do.
21	Sept. 10	15.82	.....	75.51	Do.	95	Oct. 18	14.50	1.19	74.82	Do.
22	Sept. 10	16.15	.....	77.23	Do.	96	Oct. 18	15.10	1.08	76.00	Do.
23	Sept. 10	11.90	.....	68.15	Do.	97	Oct. 18	13.30	1.45	79.62	Do.
24	Sept. 20	12.25	.....	68.82	Do.	98	Oct. 18	10.55	1.78	66.41	Do.
25	Sept. 20	13.15	.....	71.22	Do.	99	Oct. 18	11.65	1.98	70.00	Do.
26	Sept. 20	14.95	.....	80.94	Do.	100	Oct. 18	15.60	.59	69.79	Do.
31	Sept. 29	13.45	.....	70.90	Do.	101	Oct. 18	10.30	1.63	64.84	Do.
32	Sept. 29	15.15	1.18	73.18	Do.	102	Oct. 18	13.90	.76	74.77	Do.
33	Sept. 29	14.05	1.51	72.05	Do.	103	Oct. 18	8.60	1.28	46.82	Link's Hy- brid.
34	Sept. 29	13.30	1.51	72.79	Do.						Orange.
35	Sept. 29	11.95	3.43	66.44	Do.	104	Oct. 18	15.10	1.42	78.52	Do.
36	Sept. 29	12.95	1.77	71.72	Do.	105	Oct. 18	14.40	1.44	79.42	Do.
37	Sept. 29	12.60	1.56	76.23	Do.	106	Oct. 18	10.00	1.88	66.53	Do.
38	Sept. 29	15.25	1.39	76.47	Do.	107	Oct. 18	13.65	1.33	75.45	Do.
39	Sept. 29	13.00	1.80	71.23	Do.	108	Oct. 18	14.65	1.48	75.24	Do.
40	Sept. 29	16.30	1.10	75.53	Do.	109	Oct. 23	10.55	1.40	67.87	Do.
41	Sept. 29	14.30	1.87	81.27	Do.	110	Oct. 23	14.70	1.46	73.63	Do.
42	Sept. 29	14.65	.95	73.84	Do.	111	Oct. 23	12.60	1.27	69.72	Do.
43	Sept. 29	14.50	1.17	72.86	Do.	112	Oct. 23	11.30	2.13	67.62	Do.
44	Sept. 29	15.25	1.24	73.13	Do.	113	Oct. 23	16.75	1.25	76.46	Do.
45	Sept. 29	13.05	1.25	70.01	Do.	114	Oct. 23	5.85	1.35	35.83	Do.
46	Sept. 29	17.10	1.04	77.34	Do.	115	Oct. 23	12.10	1.73	62.24	Do.
48	Sept. 29	13.15	1.16	74.00	Do.						
50	Sept. 29	13.25	1.79	75.85	Orange.		Averages	14.26	1.53	71.91	
51	Sept. 29	13.65	1.73	73.64	Do.		Maxima	17.95	3.43	90.80	
52	Oct. 6	16.30	.55	76.06	Do.		Minima	5.85	.55	35.83	
53	Oct. 6	13.60	2.40	69.49	Do.						

From average sample of chips entering diffusion battery.—Fresh chip juice.

No.	Date.	Sucrose.	Glucose.	Purity.	No.	Date.	Sucrose.	Glucose.	Purity.
4	Sept. 19	12.20	.....	59.00	102	Oct. 17	13.60	1.77	70.87
6	Sept. 21	13.22	.....	67.27	108	Oct. 18	13.35	1.93	68.84
13	Sept. 26	11.85	4.25	58.6*	114	Oct. 18	12.55	1.46	68.24
16	Sept. 28	12.63	1.64	61.30	122	Oct. 19	13.60	1.50	71.28
20	Sept. 29	11.85	3.54	66.07	125	Oct. 19	13.15	1.70	69.90
28	Oct. 1	13.05	1.93	66.56	135	Oct. 20	12.85	1.80	67.70
34	Oct. 2	13.52	2.46	69.16	138	Oct. 20	9.20	1.67	50.63
35	Oct. 3	11.38	.88	59.02	145	Oct. 21	12.85	1.35	71.00
44	Oct. 6	12.32	2.17	61.58	152	Oct. 21	12.70	1.41	68.53
47	Oct. 6	12.32	2.71	63.81	157	Oct. 22	12.50	1.45	69.44
53	Oct. 7	13.00	3.79	59.38	166	Oct. 22	12.15	1.43	68.00
54	Oct. 7	13.00	3.49	59.38	168	Oct. 23	12.75	1.39	67.92
57	Oct. 7	9.46	2.16	46.61	174	Oct. 23	12.60	1.49	68.00
63	Oct. 8	15.08	3.39	76.98	178	Oct. 24	13.45	1.65	71.12
67	Oct. 14	14.76	1.65	73.85	184	Oct. 24	10.85	2.03	61.41
75	Oct. 15	12.70	1.50	70.05	190	Oct. 25	12.24	2.12	62.00
80	Oct. 15	13.00	1.42	71.86	192	Oct. 25	11.49	1.85	59.66
86	Oct. 16	12.60	1.64	70.66	199	Oct. 25	11.12	1.96	57.05
89	Oct. 16	13.40	1.63	73.29					
97	Oct. 17	12.95	1.52	70.13		Means.	12.56	1.99	63.20
101	Oct. 17	12.50	1.87	68.11					

Average samples of diffusion juice.

No.	Date.	Sucrose.	Glucose.	Purity.	No.	Date.	Sucrose.	Glucose.	Purity.
11	Sept. 20	8.65	3.79	76.56	104	Oct. 17	7.47	.72	71.17
15	Sept. 23	8.68	2.95	70.62	115	Oct. 18	9.29	.85	71.50
21	Sept. 29	7.20	2.03	63.10	120	Oct. 18	6.90	.69	72.03
21a	Sept. 29	8.80	.....	69.15	123	Oct. 19	8.11	1.69	72.34
29	Oct. 1	7.90	.80	69.23	127	Oct. 19	8.95	1.00	70.53
30	Oct. 1	7.90	.87	70.47	140	Oct. 20	6.23	.64	68.22
50	Oct. 6	8.40	1.65	68.62	148	Oct. 21	6.89	.67	62.18
58	Oct. 7	8.92	1.90	62.07	149	Oct. 21	8.58	.66	80.79
59	Oct. 7	8.55	1.73	62.10	161	Oct. 22	7.32	.71	70.00
65	Oct. 8	10.33	1.43	81.06	162	Oct. 22	9.08	.65	75.22
68	Oct. 14	8.83	1.66	59.84	171	Oct. 23	8.61	.96	69.18
77	Oct. 15	9.17	.90	72.00	180	Oct. 24	7.90	.92	71.23
81	Oct. 15	9.14	.66	71.91	183	Oct. 24	7.54	1.09	61.05
91	Oct. 16	8.48	.75	72.82	193	Oct. 25	7.93	.78	65.26
92	Oct. 16	9.07	.83	71.94					
103	Oct. 17	9.08	.95	68.78		Means	7.99	1.20	66.48

Average samples of filtered and clarified juice.

No.	Date.	Sucrose.	Glucose.	Purity.	No.	Date.	Sucrose.	Glucose.	Purity.
18	Sept. 28	7.63	1.07	65.58	105	Oct. 17	7.78	.77	73.28
22	Sept. 29	9.30	1.24	67.68	116	Oct. 18	8.48	.87	74.54
22	Sept. 29	7.60	.95	65.34	129	Oct. 19	8.21	1.00	68.00
30	Oct. 1	7.90	.87	70.47	143	Oct. 20	6.62	.53	70.53
38	Oct. 3	8.57	1.12	68.32	151	Oct. 21	7.85	.67	69.00
51	Oct. 6	6.05	1.18	57.50	164	Oct. 22	7.94	.63	71.34
60	Oct. 7	7.80	1.74	56.23	176	Oct. 23	7.95	.91	67.74
61	Oct. 7	9.10	1.75	63.46	185	Oct. 24	7.68	.90	64.97
69	Oct. 14	9.29	1.58	69.10	196	Oct. 25	8.19	.99	66.15
79	Oct. 15	8.90	.71	68.04					
95	Oct. 16	8.42	.78	72.05		Means.....	8.11	1.01	67.46

Average samples of sirups.

No.	Date.	Direct su- crose.	In- direct su- crose.	Glucose.	Purity.
12	Sept. 22	32.80	.....	10.63	58.01
14	Sept. 26	32.80	.....	.....	58.84
24	Sept. 29	32.60	32.64	9.50	60.26
25	Sept. 30	37.80	.....	9.36	64.59
26	Oct. 1	35.80	36.06	8.35	64.04
40	Oct. 4	29.40	.....	.....	63.18
62	Oct. 7	32.40	32.42	6.81	57.29
74	Oct. 15	31.75	31.94	9.96	58.16
87	Oct. 16	39.20	38.10	6.30	66.91
107	Oct. 18	37.10	35.54	5.51	68.33
121	Oct. 19	37.70	36.99	5.65	67.87
134	Oct. 20	34.00	33.43	5.75	57.94
147	Oct. 21	26.50	25.94	5.72	65.11
158	Oct. 22	32.40	31.48	5.88	73.50
177	Oct. 23	25.80	27.46	5.37	62.88
189	Oct. 25	31.00	30.29	5.85	65.34
201	Oct. 26	30.50	29.73	6.13	60.56
	Means	32.91	32.46	7.12	63.11

Average samples of first masse cuite.

No.	Date.	Brix.	Direct sucrose.	Indirect sucrose.	Glucose.	Purity.
27	Oct. 1	88.30	52.80	54.58	16.22	59.80
45	Oct. 6	89.01	58.00	56.90	11.70	65.16
76	Oct. 15	82.90	46.00	48.42	12.33	55.48
111	Oct. 18	87.60	51.50	-----	11.34	58.79
156	Oct. 21	89.00	62.00	61.66	13.25	69.62
202	Oct. 27	93.26	59.20	60.32	12.89	65.56
203	Oct. 27	92.41	59.20	60.34	9.27	64.06
205	Oct. 27	81.72	50.40	50.60	11.57	61.67
Means...		88.03	54.89	56.12	12.32	62.35

SECOND MASSE CUIE.

204	Oct. 28	87.60	46.80	49.18	14.39	53.42
206	Oct. 28	79.68	47.80	49.22	13.01	59.98
207	Oct. 29	81.72	46.40	47.92	11.57	56.77
214	Nov. 3	89.45	48.00	49.49	12.92	53.66
215	Nov. 3	87.60	48.60	49.62	11.96	55.48
Means...		85.21	47.52	49.08	12.77	55.65

Average samples of exhausted chip juice.

No.	Date.	Sucrose.	Purity.	No.	Date.	Sucrose.	Purity.
5	Sept. 19	2.17	40.42	98	Oct. 17	.62	32.28
7	Sept. 20	1.39	47.76	109	Oct. 18	.46	25.27
10	Sept. 20	.36	23.68	112	Oct. 18	.77	31.95
23	Sept. 29	.41	26.28	124	Oct. 19	.51	25.37
31	Oct. 1	.67	37.84	136	Oct. 20	1.13	45.01
33	Oct. 2	.83	43.20	142	Oct. 20	.93	41.70
36	Oct. 3	.31	18.56	144	Oct. 21	.53	51.88
46	Oct. 6	.26	15.11	154	Oct. 21	.77	47.85
48	Oct. 6	.36	22.35	159	Oct. 22	.31	25.62
55	Oct. 7	.62	30.00	160	Oct. 22	.31	25.62
64	Oct. 8	1.55	61.27	169	Oct. 23	.41	28.09
66	Oct. 14	.50	27.83	170	Oct. 23	.76	36.01
73	Oct. 15	.50	35.46	181	Oct. 24	.56	33.53
78	Oct. 15	.35	24.00	191	Oct. 25	.41	31.29
85	Oct. 16	.75	31.51	198	Oct. 25	.41	27.15
88	Oct. 16	.57	30.00	Means.....		.60	32.63
90	Oct. 16	.62	35.23				

Summary of results of chemical control at Attica, Kansas, 1890.

Cane purchased	tons..	1,305.30
Do	pounds..	2,610,723.00
Cane spoilt on carrier due to "shut down"	do	40,087.00
Do	tons..	20.04
Clean cane	tons..	900.20
Do	pounds..	1,800,529.00
Loss in weight due to cleaning	tons..	405.10
Do	pounds..	770,107.00
Do	per cent..	30.73
Amount of—		
Clean cane diffused	tons..	900.20
Do	pounds..	1,800,529.00
Juice in clean cane	do	1,620,476.10
Do	gallons..	179,542.80
Sucrose in clean cane, juice	pounds..	214,835.00

Amount of—

Glucose in clean cane, juice	do	34, 038. 00
Sucrose per ton of clean cane	pounds..	238. 60
Glucose per ton of clean cane	do	37. 89
Sucrose per ton of field cane	do	164. 60
Glucose per ton of field cane	do	26. 50

Sucrose in exhausted chips—

Regular draw	do	8, 344. 00
Last 8 cells	do	4, 056. 00
Total	do	12, 400. 00
Regular draw	per cent..	0. 60
Last 8 cells	do	0. 99

Per cent extraction	do	95. 33
---------------------------	----------	--------

Loss of sucrose, due to leaky heaters	pounds..	45, 438. 50
---	----------	-------------

Amount of—

Skimmings returned to battery	gallons..	7, 877. 00
Do	pounds..	66, 965. 00
Sucrose in skimmings	do	2, 551. 00
Glucose in skimmings	do	448. 00
Diffusion juice, regular draw	gallons..	148, 850. 00
Do	pounds..	1, 283, 812. 00
Diffusion juice last 8 cells	gallons..	96, 084. 00
Do	pounds..	822, 097. 00
Sucrose in diffusion juice, regular draw	do	102, 576. 50
Glucose in diffusion juice, regular draw	do	15, 405. 00
Sucrose in diffusion juice, last 8 cells	do	56, 971. 00
Glucose in diffusion juice, last 8 cells	do	6, 740. 00

Total weight of sucrose in diffusion juice	do	169, 547. 50
--	----------	--------------

Total weight of glucose in diffusion juice	do	22, 146. 00
--	----------	-------------

Actual weight of sucrose—sucrose of diffusion juice—sucrose in skim-		
mings	pounds..	156, 996. 50

Actual weight of glucose—glucose of diffusion juice—glucose in skim-		
mings	pounds..	21, 698. 00

Total weight of clarified juice	do	1, 283, 812. 00
---------------------------------------	----------	-----------------

Total loss of sucrose juice due to manipulation and inversion		None.
---	--	-------

Total loss of sucrose as skimming		Not estimated.
---	--	----------------

Total loss of sucrose in juice, before and after leaving triple effect,		
pounds		7, 752. 60

Total amount of—

Sugar obtained as firsts	do	36, 050. 00
Sugar, per ton of field cane	do	28. 90
Sugar, per ton of clean cane	do	40. 04
Second masse cuite	gallons..	8, 237. 28
Do	pounds..	101, 708. 00
Sucrose in second masse cuite	do	49, 928. 70
Glucose in second masse cuite	do	12, 988. 00
Remaining unboiled "first molasses"	do	32, 552. 60
Sucrose in unboiled "first molasses"	do	11, 484. 50
Glucose in unboiled "first molasses"	do	4, 203. 70
On hand	do	97, 463. 20
Sucrose burned, due to poor boiling	do	15, 731. 30

OPERATIONS AT FORT SCOTT, KANSAS.

The chemical work at Fort Scott was conducted by Mr. E. E. Ewell.

In all, 1,115 acres of cane were contracted for by the company; 7,575 tons were received, the weight being taken after the removal of the seed heads. This showed an average yield of 6.875 tons per acre. One-third of the total amount was Early Amber cane, and the remainder, with the exception of 100 acres of Link's Hybrid, was Orange cane.

The season was dry in the early part, but the latter part of it was wet. The wet weather coming late in the season was of great benefit to the late canes, but caused a second growth of the more mature.

The total amount of sugar made was 356,365 pounds, and the amount of molasses approximately 95,000 gallons. The average yield of sugar per ton was 48.5 pounds, after deducting 230 tons of cane which were worked for molasses alone. The average yield of molasses per ton was 14.5 gallons.

One thousand seven hundred and twenty tons of coal were consumed during the entire season.

The work during the season was retarded by many accidents to the machinery; the largest number of diffusion cells worked in 24 hours being 134. Had this rate of work continued, only 52 days would have been consumed in the campaign instead of 74.

The chief causes of delay were a lack of capacity in the multiple-effect evaporator and an insufficient supply of cane. Most of the delays experienced could have been avoided by a thorough overhauling of the machinery during the 9 months it was lying idle.

By allowing the clarified juice to stand in settling tanks a large amount of sediment was removed, and this was returned to the battery.

The analytical data obtained will be found in detail in the following tables:

Analyses of average samples of sirups, massecuites, and sugars.

Date boiled.	Striko No.	Sirups.				Massecuites.				Sugars.		
		Solids.	Su- crose.	Gluc- cose.	Purity	Solids.	Su- crose.	Gluc- cose.	Purity	Date.	Su- crose.	Wt.
1890.		<i>Pr. ct.</i>	<i>Pr. ct.</i>	<i>Pr. ct.</i>		<i>Pr. ct.</i>	<i>Pr. ct.</i>	<i>Pr. ct.</i>			<i>Pr. ct.</i>	
Sept. 10	13	51.18	31.20	.....	60.80	90.10	57.80	.....	64.20	Sept. 18	96.00	.....
Sept. 11	14	46.00	.....	.....	.....	90.75	57.40	14.45	63.30	Sept. 20	94.60	.....
Sept. 14	15	57.18	32.04	.....	56.30	88.76	50.20	.....	56.60	Sept. 24	91.90	.....
Sept. 15	16	52.70	32.10	.....	60.90	89.49	56.60	.....	62.20	.....	.....	.....
Sept. 16	17	50.42	28.90	10.00	57.70	90.04	51.70	.....	57.40	Sept. 25	95.40	.....
Sept. 17	18	50.20	31.20	8.16	62.10	91.38	56.80	.....	62.20	Sept. 26	92.70	.....
Sept. 18	19	52.00	31.50	9.30	60.60	89.53	54.20	.....	60.54	Sept. 28	93.40	.....
Sept. 19	20	51.32	30.10	10.26	58.70	90.70	53.20	.....	58.65	Sept. 29	93.90	.....
Sept. 20	21	51.60	29.60	10.70	57.90	90.39	53.20	18.84	58.85	Sept. 20	92.20	.....
Sept. 21	22	49.50	29.25	9.39	59.10	90.49	54.24	18.10	59.94	Sept. 30	93.10	.....
Sept. 22	23	50.52	30.20	8.96	59.80	90.48	54.46	17.47	60.19	Oct. 1	92.30	.....
Sept. 23	24	51.24	.....	9.58	.....	90.17	54.28	17.66	60.19	Oct. 2	91.40	.....
Sept. 24	25	48.93	30.04	7.84	61.40	89.55	55.96	14.88	62.49	Oct. 4	91.00	.....
Sept. 25	26	51.44	32.48	7.60	63.10	.....	56.78	.....	.....	Oct. 5	91.50	.....
Sept. 26	27	48.76	30.49	6.87	62.30	89.58	57.72	13.50	64.43	Oct. 6	92.90	.....
Sept. 28	28	53.51	32.39	7.90	60.50	89.95	55.88	12.50	62.12	Oct. 7	84.40	.....
Sept. 30	29	54.49	35.17	7.72	64.50	90.72	57.76	14.00	63.66	Oct. 8	91.49	.....
Oct. 1	30	47.23	30.15	6.85	63.80	.....	57.12	13.50	.....	Oct. 10	97.20	.....
Oct. 2	31	49.35	30.79	7.91	62.40	90.95	56.08	15.03	61.66	Oct. 11	94.10	.....
Oct. 3	32	44.18	28.19	6.83	63.80	89.76	55.52	13.69	61.85	Oct. 12	94.10	.....
Oct. 4	33	43.50	27.44	7.23	63.10	90.20	56.75	14.25	62.90	Oct. 12	95.70	.....
Oct. 5	34	.....	.....	.....	.....	90.10	56.06	14.76	62.20	Oct. 13	96.10	.....
Oct. 6	35	46.07	28.71	7.86	62.30	89.56	54.82	14.66	61.20	Oct. 14	95.00	.....
Oct. 8	36	.....	.....	.....	.....	89.39	54.94	15.03	61.50	Oct. 14	94.90	.....
Oct. 9	37	54.96	34.35	9.13	62.50	88.93	55.30	15.88	62.20	Oct. 15	94.80	.....
Oct. 10	38	.....	.....	.....	.....	88.80	53.10	17.66	59.80	Oct. 16	94.20	.....
Oct. 11	39	57.62	34.80	11.58	60.40	90.20	53.76	17.66	59.00	Oct. 17	92.30	.....
Oct. 12	40	.....	.....	.....	.....	88.20	52.58	.....	59.60	Oct. 17	93.70	.....
Oct. 13	41	54.50	32.17	11.25	59.50	88.60	51.52	.....	58.20	Oct. 18	93.90	.....
Oct. 14	42	.....	.....	.....	.....	87.90	52.96	.....	60.30	Oct. 19	93.20	.....
Oct. 15	43	52.00	32.05	9.25	61.60	88.70	55.24	.....	62.30	Oct. 20	94.80	.....
Oct. 16	44	54.84	35.55	8.75	64.80	88.70	56.10	.....	63.20	Oct. 22	92.70	.....
Oct. 17	45	.....	.....	.....	.....	87.70	54.68	.....	62.30	Oct. 23	95.20	.....
Oct. 18	46	51.12	32.36	7.91	63.30	88.60	55.62	.....	62.80	Oct. 24	96.10	.....
Oct. 19	47	.....	.....	.....	.....	89.40	53.28	.....	59.60	Oct. 24	95.80	.....
Oct. 20	48	46.47	27.94	8.36	60.10	88.80	53.96	.....	60.80	Sept. 10	92.30	9
Oct. 21	49	.....	.....	.....	.....	89.40	55.36	.....	61.90	Sept. 12	93.70	10
Oct. 22	50	40.07	31.39	7.89	63.90	93.00	57.14	.....	61.40	Sept. 15	92.50	11
Oct. 23	51	.....	.....	.....	.....	.....	.....	.....	.....	Sept. 19	94.10	12
Oct. 24	52	48.80	32.41	.....	66.40	.....	.....	.....	.....	.....	.....	.....
Minima	.....	43.50	27.44	6.87	56.30	87.70	50.20	12.50	56.60	.....	84.40	.....
Maxima	.....	57.62	35.55	11.58	66.40	93.00	57.80	18.84	64.43	.....	97.20	.....
Means	.....	50.67	31.21	8.65	61.59	89.69	55.00	15.45	61.20	.....	93.50	.....

Analyses of average samples of juice of exhausted chips.

Date.	Sucrose.	Sucrose, average for day.	Date.	Sucrose.	Sucrose, average for day.	Date.	Sucrose.	Sucrose, average for day.
1890.	<i>Per cent.</i>	<i>Per cent.</i>	1890.	<i>Per cent.</i>	<i>Per cent.</i>	1890.	<i>Per cent.</i>	<i>Per cent.</i>
Sept. 9	1.15	1.15	Sept. 21	.88	.....	Oct. 9	.....	.99
Sept. 10	.92	.....	Sept. 21	.88	.88	Oct. 10	.....	.76
Sept. 10	1.40	.....	Sept. 22	.72	.....	Oct. 11	1.44	.....
Sept. 10	.31	.88	Sept. 22	.66	.....	Oct. 11	.68	1.06
Sept. 11	.31	.....	Sept. 22	.66	.68	Oct. 12	.51	.51
Sept. 11	.40	.....	Sept. 23	.46	.....	Oct. 13	.79	.79
Sept. 11	.46	.39	Sept. 23	.57	.52	Oct. 14	.82	.82
Sept. 12	.31	.31	Sept. 27	.41	.41	Oct. 15	1.27	1.27
Sept. 13	.41	.....	Sept. 28	.72	.72	Oct. 16	.65	.65
Sept. 13	.52	.....	Sept. 29	.68	.....	Oct. 17	1.18	1.18
Sept. 13	.67	.53	Sept. 29	.37	.53	Oct. 18	.63	.....
Sept. 14	.62	.62	Sept. 30	.40	.....	Oct. 18	.60	.62
Sept. 15	.57	.....	Sept. 30	.68	.54	Oct. 20	.65	.....
Sept. 15	1.20	.89	Oct. 1	.74	.....	Oct. 20	.88	.77
Sept. 16	1.00	.....	Oct. 1	.57	.66	Oct. 21	.....	1.10
Sept. 16	1.20	1.10	Oct. 2	.71	.....	Oct. 22	.93	.....
Sept. 17	1.19	.....	Oct. 2	.91	.....	Oct. 22	.79	.86
Sept. 17	.67	.93	Oct. 2	.46	.69	Oct. 23	.....	.99
Sept. 18	.41	.....	Oct. 3	.....	.79	.....	.....	.....
Sept. 18	.41	.41	Oct. 4	.....	.74	Minimum	.....	.31
Sept. 19	.77	.77	Oct. 7	.....	.82	Maximum	.....	1.27
Sept. 20	.77	.77	Oct. 8	.....	.71	Mean	.....	.74

Analyses of average samples of clarified juice.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Oct. 9	16.11	3.63	.....	59.80	Oct. 20†	17.28	11.60	.....	67.13
Oct. 12	15.30	9.05	.....	59.08	Oct. 21‡	15.30	9.96	1.82	65.14
Oct. 13	16.76	10.40	2.44	62.06	Oct. 22	15.33	10.12	1.66	66.18
Oct. 14*	13.46	9.19	.....	68.24	Oct. 23	15.89	10.56	.....	66.50
Oct. 15	14.86	9.49	1.81	63.80					
Oct. 16	15.27	9.42	1.83	61.60	Means ..	15.53	9.81	2.06	63.16
Oct. 17	16.09	10.07	2.16	62.58	Maxima.	17.28	11.60	2.45	68.24
Oct. 18	14.79	8.66	2.34	58.53	Minima.	13.46	8.66	1.66	58.53
Oct. 19	15.49	9.38	2.45	60.55					

* Sample not strictly comparable with sample of diffusion juice.

† 6 barrels refuse sugar added.
‡ 1½ barrels refuse sugar added.

Analyses of average samples.

Normal acetate of lead was used as a preservative from September 9 to October 8, inclusive. Basic acetate of lead was used as a preservative from October 9 to October 23, inclusive.

Date.	Normal juice from chips entering battery.				Diffusion juice.				Actual dilution in battery.
	Solids.	Sucrose.	Glucose.	Purity.	Solids.	Sucrose.	Glucose.	Purity.	
1890.	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>		
Sept. 9	16.73	10.78	.....	64.3	12.47	8.42	.....	67.4	34.2
Sept. 10	15.21	9.05	.....	59.5	12.26	8.05	.....	65.3	24.1
Sept. 11	16.83	10.12	.....	50.02	11.37	7.43	.....	65.3	48.0
Sept. 11	16.73	9.70	.....	57.9	11.50	7.25	2.04	63.04	45.5
Sept. 12	16.94	8.63	3.28	50.9	12.05	7.15	2.06	59.3	27.9
Sept. 13	16.52	10.34	2.37	62.6	12.51	7.44	1.88	59.50	36.4
Sept. 15	16.11	9.52	2.79	59.1	11.65	7.37	1.98	63.3	31.7
Sept. 16	15.56	9.63	2.75	61.9	11.43	7.37	1.86	64.5	34.1
Sept. 17	16.63	9.35	3.74	56.2	12.38	7.37	2.37	59.5	34.4
Sept. 18	16.80	9.19	4.35	54.1	12.78	7.15	2.82	55.9	35.8
Sept. 19	17.08	9.90	3.17	57.9	13.09	7.81	2.65	59.6	24.9
Sept. 20	17.24	10.34	3.21	59.9	12.76	7.76	2.56	60.8	31.3
Sept. 21	16.14	9.63	3.25	59.6	12.95	8.18	2.58	63.16	19.7
Sept. 22	16.88	11.20	2.55	66.3	13.13	8.62	2.05	65.7	28.8
Sept. 23	17.10	10.98	2.76	64.2	13.53	8.74	2.16	64.6	26.1
Sept. 24	16.80	10.74	2.70	63.93	13.26	8.52	2.13	64.25	26.2
Sept. 25	16.30	10.29	2.65	63.13	13.77	8.69	2.42	63.11	16.4
Sept. 26†	16.28	9.96	2.72	61.13	13.0	8.41	2.08	64.60	20.9
Sept. 27†	16.85	10.45	2.32	62.18	13.27	8.31	2.07	62.62	23.0
Sept. 29	16.99	10.45	.....	61.51	13.08	8.36	2.00	63.91	29.9
Sept. 30	17.90	11.04	2.52	64.01	14.41	9.36	2.37	64.95	15.6
Oct. 1	16.62	10.56	2.85	63.54	13.52	8.60	2.16	63.61	24.6
Oct. 2	16.73	10.56	2.58	63.12	14.80	9.56	2.40	64.59	10.9
Oct. 3	16.75	10.51	2.58	62.75	13.74	8.63	2.20	62.81	20.9
Oct. 4	16.26	9.07	3.11	55.78	13.64	8.58	2.29	62.9	12.1
Oct. 7	16.93	10.96	.....	64.7	13.05	8.13	.....	62.3	29.7
Oct. 8	19.23	11.18	.....	58.09	15.73	9.45	.....	60.06	22.2
Oct. 9	18.93	11.66	.....	61.59	15.35	9.29	.....	60.52	25.5
Oct. 10	18.60	11.50	2.72	61.83	14.58	8.58	2.52	58.85	28.1
Oct. 11	.....	.....	.....	.....	15.17	8.69	2.82	57.28	.....
Oct. 12	18.89	11.51	.....	60.87	14.85	8.66	.....	58.31	27.8
Oct. 13	17.97	11.83	2.12	65.83	15.51	9.71	2.17	62.6	17.4
Oct. 14	18.96	12.59	1.93	66.43	13.72	8.75	1.63	63.74	39.9
Oct. 15	18.93	11.99	2.25	63.3	14.75	9.24	1.98	62.5	26.8
Oct. 16	18.55	12.21	2.24	65.8	14.99	9.35	2.00	62.3	27.3
Oct. 17	19.00	12.27	2.42	64.68	15.46	9.38	2.24	60.67	26.4
Oct. 18	18.91	10.73	3.62	56.74	15.09	8.53	2.66	56.53	28.2
Oct. 19	19.19	12.32	2.42	64.20	15.34	9.30	2.31	60.63	27.0
Oct. 20	18.30	12.60	1.93	68.85	14.71	9.43	1.88	64.11	28.5
Oct. 21	17.61	11.99	1.71	68.09	14.56	9.43	1.72	64.76	22.9
Oct. 22	17.57	12.21	1.66	69.49	14.67	9.63	1.72	65.65	22.2
Oct. 23	17.86	12.10	.....	67.64	15.28	10.07	.....	66.05	16.9
Minima*	15.21	8.63	1.66	50.02	11.37	7.15	1.63	55.9	10.9
Maxima*	19.23	12.60	4.35	69.49	15.51	10.07	2.82	67.4	48.0
Means *	17.33	10.77	2.69	62.15	13.69	8.54	2.20	62.38	26.8
Minima†	15.21	8.63	2.32	50.02	11.37	7.15	1.86	55.9	10.9
Maxima†	19.23	11.20	4.35	64.7	14.80	9.56	2.82	67.4	48.0
Means †.	16.71	10.15	2.91	60.74	13.00	8.18	2.14	62.92	27.2
Minima‡	16.26	10.73	1.66	56.74	13.72	8.53	1.63	56.53	12.1
Maxima‡	19.19	12.60	3.62	69.49	15.51	10.07	2.82	66.05	39.9
Means ‡.	18.52	11.97	2.27	64.63	14.94	9.20	2.24	61.58	26.1

* For the season.

† From October 9 to October 23, inclusive.

‡ From September 9 to October 8, inclusive.

OPERATIONS OF THE TOPEKA FACTORY.

The chemical work at Topeka was in charge of Mr. Oma Carr, assisted by Mr. Lewis H. Bradford.

The Topeka Sugar Factory, which was destroyed by fire last year, was rebuilt during the present season and operated for the manufacture of sugar.

Difficulties of various kinds, but in no wise inherent to the process of manufacture, caused delays in the operations of the factory, and rendered its work expensive. The supply of steam was not sufficient for the full working extent of the rest of the machinery, and the multiple effect pans were provided with very low domes, which rendered successful boiling difficult. Moreover, the fuel employed was of particularly bad quality. The pumping arrangements were found inadequate to provide an abundant supply of water.

The crop of cane was somewhat later in maturing than usual, due to the autumnal rains following a very dry summer. The crop ripened in a very irregular way, thus causing to be delivered to the factory canes in various stages of maturity. The amber cane reached its maximum maturity about the middle of September, and the orange cane about the middle of October.

The battery work was extremely irregular, the percentages of dilution ranging from 8 to 14, and the percentages of extraction of sugar from 80 to 95 per cent. The percentages of sucrose in the exhausted chips vary from 0.5 per cent to 2 per cent; the number of diffusion cells worked daily varied from twenty-three to one hundred and four, and the loss of time daily by stoppages was from 2 to 14 hours. Under such irregular conditions of work, due generally to the causes already mentioned, it is not strange that attempts at the successful manufacture of sugar at a profit were fruitless.

MANUFACTURING DATA.

Cane contracted for by the company.....	acres..	1,200
Cane delivered to the mill	do...	1,000
Weight of cane delivered.....	tons..	6,412
Yield of cane per acre.....	do...	6.41
Total amount of sugar made	pounds..	278,687
Yield of sugar, per ton of field cane.....	do...	43.57

By the term "field cane" is meant the cane with its blades and tops. The average amount of clean chips afforded by such cane is 75 per cent of the total weight. The amount of clean cane, therefore, entering the battery under this estimate was 4,809 tons. The yield of sugar per ton of clean cane chips was therefore nearly 58 pounds.

The sampling of the chips entering the battery was made in the usual way so as to secure a fair average of the cane worked. The analyses of these samples were commenced on the 10th of September and were continued until the close of the house on the 8th of November.

Forty-seven samples of fresh chips were analyzed with the following mean results:

In the juice.

Total solids	per cent..	15.97
Sucrose	do....	10.15
Glucose	do....	2.14
Purity		63.56

A mere glance at these figures will show that the cane was in a very poor condition for sugar-making purposes. This was due to the causes already stated, namely, the autumnal rains, which prevented the cane from properly maturing, and the fact that the fields were planted with mixed seeds so that some of the cane was mature at a much earlier period, and doubtless the principal cause was imperfect cultivation. The poor character of the chips for sugar-making purposes is illustrated in a striking way by comparing the analyses of them with the analyses of chips from cane in other parts of the State. Considering the character of the material worked, the yield per ton must be considered as quite satisfactory.

Twenty-seven analyses of the exhausted chips were made, showing a mean percentage of sugar therein of 1.77. This result shows very poor battery work. A mean percentage of sugar in the exhausted chips of more than 0.5 per cent shows some grave defect in the method of working. This defect is usually due to imperfect chipping; the shredders become dull, allowing large pieces of cane to go through unshredded, the internal portions of which are protected from the diffusion process. With chips properly prepared and the temperature of the battery properly regulated there is no difficulty whatever in securing extraction which will leave 0.5 per cent or less of sugar in the bagasse.

Fifty analyses of average samples of the diffusion juice were made, with the following mean results:

Total solids	per cent..	12.99
Sucrose	do....	8.54
Glucose	do....	1.67
Purity		67.39

Forty-eight analyses of the clarified juices were made, with the following mean results:

Total solids	per cent..	13.23
Sucrose	do....	8.91
Glucose	do....	1.57
Purity		68.49

Twenty-five analyses of the sirups entering the vacuum pan were made, with the following mean results:

Total solids	per cent..	38.58
Sucrose	do....	25.24
Glucose	do....	3.94
Purity		64.69

For convenience of reference the work of the factory was divided into three periods, namely: First period, from September 10 to 20; second period, from September 20 to October 15; third period, from October 15 to October 30, not including the last two days of the run in November. The mean data for the three periods are as follows:

Fresh chip juice.

	First period.	Second period.	Third period.
Total solids per cent..	16.58	16.09	16.67
Sucrose do....	10.02	10.38	11.18
Glucose do....	2.68	1.81	1.84
Solids not sugar..... do....	3.94	3.90	3.65
Glucose ratio	26.15	17.44	16.45
Purity coefficient.....	60.43	64.51	67.67

The means for the whole season, excluding the November run, are—

Total solids..... per cent..	16.32
Sucrose do....	10.54
Glucose do....	1.92
Solids not sugar do....	3.86
Glucose ratio	18.22
Purity coefficient	64.56

The constant improvement of the material entering the battery from the beginning to the end of the season is strikingly illustrated by the above figures. We find the same fact true of sorghum that is illustrated in sugar cane, that the longer the season for manufacturing can be delayed the richer the material in sugar will become. With an average of 10.5 per cent. sugar in the juice and 9.45 per cent. sugar in the cane the total amount of sucrose in a ton of clean chips is 189 pounds and the amount obtained in a merchantable form of the raw sugar, as indicated above, is 58 pounds, which would amount to about 55 pounds of pure sugar.

The results illustrate the striking loss in sorghum sugar manufacture as heretofore carried on, viz, a loss of 134 pounds of sucrose for each ton of clean chips worked. This loss, as has already been pointed out repeatedly, is due to the pernicious effects of the reducing sugars' and matters not sugars present in the juice, such matters, as shown by our work during the present year, having amounted to 3.86 per cent. of the weight of the juice. It is perfectly safe to say that the total loss of sugar in the molasses was almost exclusively due to the presence of these matters in the juice. It is evident at once that the financial success of sorghum sugar manufacture must follow some method of work which would largely eliminate these sources of loss.

The analytical details of the season's work follow in tabular form.

Juice from average samples of fresh chips.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Sept. 10	15.93	10.45	.....	65.47	Oct. 11	15.97	9.83	2.39	61.55
Sept. 11	14.61	9.56	.....	65.43	Oct. 12	15.66	9.78	2.46	62.40
Sept. 15	18.03	11.64	1.43	64.50	Oct. 13	15.98	9.75	1.97	61.01
Sept. 16	16.98	11.19	1.58	65.90	Oct. 14	14.39	9.46	1.74	65.70
Sept. 17	17.69	10.71	3.77	60.50	Oct. 15	16.13	11.29	1.82	69.60
Sept. 18	18.11	9.05	3.86	50.00	Oct. 16	17.12	11.79	1.40	68.86
Sept. 19	14.38	6.88	3.19	47.0	Oct. 17	17.38	11.42	1.70	65.70
Sept. 20	17.82	11.05	1.50	62.0	Oct. 18	16.84	11.51	1.50	68.30
Sept. 21	16.87	10.65	1.87	63.0	Oct. 19	16.84	11.79	1.96	70.00
Sept. 23	18.72	11.75	2.02	62.76	Oct. 20	19.17	12.86	1.22	67.1
Sept. 24	10.52	6.43	1.25	61.12	Oct. 21	14.80	10.44	1.56	70.5
Sept. 25	17.28	10.54	1.69	60.90	Oct. 22	17.81	12.71	1.93	71.4
Sept. 26	15.42	9.97	1.76	64.65	Oct. 23	16.56	10.17	1.75	61.41
Sept. 27	14.87	8.16	1.88	55.6	Oct. 24	17.20	9.52	2.79	55.60
Sept. 28	18.04	7.76	.....	43.15	Oct. 26	16.03	9.92	2.28	61.88
Sept. 29	16.53	10.46	2.34	63.20	Oct. 27	17.14	11.01	2.00	63.06
Sept. 30	17.31	11.67	1.67	67.40	Oct. 28	17.29	11.00	1.95	63.27
Oct. 1	14.89	9.62	1.38	64.67	Nov. 3	16.57	9.55	1.81	51.62
Oct. 2	16.51	10.99	1.47	66.50	Nov. 4	17.24	9.16	4.72	53.13
Oct. 4	17.81	10.35	2.45	66.90	Nov. 6	15.57	9.45	2.31	60.69
Oct. 5	15.53	9.59	1.89	61.70	Nov. 7	16.47	9.41	5.27	57.12
Oct. 6	13.34	9.10	1.17	67.50	Nov. 8	16.09	9.46	4.41	58.70
Oct. 7	15.67	10.22	.....	65.20	Means..	15.97	10.15	2.14	63.56
Oct. 8	15.89	9.44	1.51	59.00					
Oct. 9	17.50	8.51	2.16	48.62					

Average samples of diffusive juice.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Sept. 5	9.58	6.04	.....	63.04	Oct. 10	13.25	7.51	.....	69.2
Sept. 8	9.97	6.22	.....	62.18	Oct. 12	12.74	8.39	1.77	65.8
Sept. 9	10.35	7.27	.....	70.24	Oct. 13	12.25	8.46	1.22	69.06
Sept. 10	7.49	5.01	.....	66.78	Oct. 14	12.98	9.79	1.29	75.4
Sept. 11	10.40	6.52	.....	62.69	Oct. 15	13.27	9.66	1.49	72.8
Sept. 15	8.96	6.39	1.26	71.3	Oct. 16	12.79	9.49	1.29	74.1
Sept. 16	5.85	3.87	.406	66.1	Oct. 17	14.29	10.27	1.76	71.1
Sept. 18	9.82	5.96	3.86	50.0	Oct. 18	14.35	10.30	1.72	71.7
Sept. 19	9.27	5.39	1.41	58.1	Oct. 19	14.65	9.97	.....	68.0
Sept. 20	8.17	4.92	.563	60.2	Oct. 20	13.85	10.87	1.71	78.5
Sept. 21	8.51	5.69	1.33	67.0	Oct. 21	13.49	9.75	1.42	72.2
Sept. 23	9.46	6.40	1.03	67.70	Oct. 22	14.33	9.87	1.46	68.8
Sept. 25	9.22	5.48	1.04	59.4	Oct. 23	13.59	9.89	1.63	72.7
Sept. 26	12.32	8.37	1.48	67.93	Oct. 24	14.06	8.18	2.15	58.2
Sept. 27	13.66	9.67	1.69	70.07	Oct. 26	14.53	9.67	2.41	66.56
Sept. 28	13.73	9.67	1.91	70.4	Oct. 27	14.74	10.37	1.80	70.3
Sept. 29	12.71	8.26	1.85	65.0	Oct. 28	14.47	10.34	1.47	72.15
Sept. 30	14.80	9.62	2.05	65.0	Nov. 3	12.05	8.12	1.47	67.38
Oct. 1	13.15	8.95	1.43	67.5	Nov. 4	14.56	9.62	1.62	66.07
Oct. 2	13.35	9.13	1.79	68.3	Nov. 5	14.91	9.95	2.15	66.7
Oct. 3	11.75	7.98	1.72	67.9	Nov. 6	14.85	9.01	1.80	66.70
Oct. 4	14.20	9.49	2.34	66.9	Nov. 7	13.85	9.38	1.96	67.72
Oct. 5	14.87	8.86	1.48	59.5	Nov. 8	11.85	7.47	1.65	63.01
Oct. 6	13.05	9.03	1.64	69.2	Means..	12.99	8.54	1.67	67.39
Oct. 8	13.83	9.69	1.78	70.1					
Oct. 9	13.97	8.70	2.85	66.8					

Average samples of clarified juice.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Sept. 5	9.95	6.34	-----	63.72	Oct. 11	14.71	10.91	1.04	71.3
Sept. 8	10.99	7.14	-----	64.92	Oct. 12	13.78	9.39	1.74	68.1
Sept. 9	10.63	7.42	-----	69.47	Oct. 13	12.35	8.51	.99	68.90
Sept. 10	8.71	5.80	-----	66.58	Oct. 14	14.81	10.93	1.42	73.8
Sept. 11	10.85	6.73	-----	62.03	Oct. 15	13.91	9.92	1.31	71.3
Sept. 15	8.95	5.54	1.20	61.9	Oct. 16	14.03	10.20	1.28	72.3
Sept. 16	6.41	4.00	.66	62.4	Oct. 17	14.93	10.22	1.45	68.6
Sept. 18	10.31	6.89	1.99	61.9	Oct. 18	15.09	10.60	1.33	70.2
Sept. 20	8.96	5.56	.634	62.05	Oct. 19	15.13	10.73	1.63	70.9
Sept. 22	10.96	7.62	1.11	69.50	Oct. 20	14.35	10.94	1.25	76.2
Sept. 25	10.37	7.05	1.02	67.9	Oct. 21	14.49	9.87	1.45	68.0
Sept. 26	12.78	9.65	1.37	75.58	Oct. 22	14.69	10.52	1.35	72.5
Sept. 27	14.32	10.24	1.39	71.6	Oct. 23	15.14	11.19	1.52	73.8
Sept. 28	14.97	10.01	1.85	68.0	Oct. 24	15.93	8.78	2.34	55.1
Sept. 29	13.37	8.56	1.93	64.0	Oct. 26	15.03	9.72	2.30	64.66
Sept. 30	14.09	10.01	1.66	71.0	Oct. 27	15.44	10.39	1.88	67.3
Oct. 1	14.07	9.57	1.58	73.1	Oct. 28	15.43	10.42	1.51	67.50
Oct. 2	13.97	9.44	1.41	67.5	Nov. 3	12.15	7.88	1.24	64.85
Oct. 3	13.95	8.40	1.26	60.2	Nov. 4	15.04	10.39	1.64	69.08
Oct. 4	15.01	9.91	1.88	66.0	Nov. 5	15.81	10.19	1.79	64.5
Oct. 5	15.07	9.06	1.74	60.0	Nov. 6	16.07	9.85	1.95	61.29
Oct. 6	12.80	9.18	-----	71.7	Nov. 7	14.72	9.46	1.88	64.26
Oct. 7	11.78	7.43	1.84	63.07	Nov. 8	12.72	7.60	1.66	59.74
Oct. 8	14.38	9.34	1.98	64.9					
Oct. 9	14.26	9.06	2.39	63.5	Means..	13.23	8.91	1.57	68.49

Average samples of semi-sirup.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sept. 5	34.63	24.33	-----	70.25	Oct. 4	35.97	21.8	5.32	60.66
Sept. 10	43.61	31.68	-----	72.64	Oct. 6	33.58	22.0	4.10	65.6
Sept. 11	29.10	19.44	-----	66.80	Oct. 8	38.69	24.0	4.67	62.03
Sept. 17	30.11	20.27	4.70	67.3	Oct. 11	34.28	21.4	5.04	51.24
Sept. 19	40.53	24.60	6.15	60.6	Oct. 12	37.32	24.2	5.50	64.75
Sept. 20	37.75	24.89	5.83	65.93	Oct. 16	33.04	21.6	3.76	65.37
Sept. 24	40.25	26.64	2.86	66.19	Oct. 18	42.90	29.2	6.34	68.06
Sept. 25	35.29	20.97	4.81	59.0	Oct. 21	32.39	22.4	3.75	69.15
Sept. 26	44.98	28.12	5.59	62.50	Oct. 26	36.18	23.2	5.38	64.11
Sept. 27	41.57	28.14	4.72	67.7	Oct. 28	37.97	26.2	4.31	68.99
Sept. 29	46.76	29.5	-----	61.0	Nov. 7	48.06	32.0	5.17	66.58
Sept. 30	41.00	27.6	3.24	67.30					
Oct. 2	42.28	26.0	5.64	61.40	Means..	38.58	25.24	3.94	64.69
Oct. 3	46.47	28.9	5.88	62.2					

Average samples of juice of exhaust chips.

Date.	Solids.	Sucrose.	Date.	Solids.	Sucrose.	Date.	Solids.	Sucrose.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Sept. 10	2.32	.605	Oct. 3	1.53	.54	Oct. 22	3.93	2.30
Sept. 11	2.76	1.70	Oct. 4	2.72	1.36	Oct. 23	2.47	2.25
Sept. 15	3.22	2.20	Oct. 5	2.22	.568	Oct. 24	5.26	3.57
Sept. 16	3.28	1.81	Oct. 6	1.65	1.17	Oct. 25	2.44	1.13
Sept. 17	4.49	2.29	Oct. 7	1.37	.375	Oct. 26	3.94	2.60
Sept. 18	2.31	1.33	Oct. 8	1.88	1.05	Oct. 27	5.70	2.85
Sept. 19	1.93	.911	Oct. 9	2.56	.878	Oct. 28	5.44	3.08
Sept. 20	3.02	1.60	Oct. 10	2.06	1.72	Nov. 3	3.56	2.09
Sept. 21	-----	1.05	Oct. 12	3.09	1.72	Nov. 4	3.64	1.32
Sept. 23	4.07	2.00	Oct. 13	2.87	1.41	Nov. 5	3.16	2.51
Sept. 24	2.02	.740	Oct. 14	2.21	1.10	Nov. 6	2.16	1.45
Sept. 26	2.97	1.27	Oct. 15	3.22	1.52	Nov. 7	3.44	2.01
Sept. 27	1.51	.42	Oct. 16	2.16	1.25	Nov. 8	4.66	3.28
Sept. 28	1.37	.55	Oct. 18	3.01	1.19			
Sept. 30	1.96	1.08	Oct. 19	2.26	.96	Mean...	2.91	1.77
Oct. 1	2.76	1.33	Oct. 20	4.21	2.70			
Oct. 2	2.21	1.19	Oct. 21	2.63	1.87			

Averages for three periods of season of 1890, Topeka Sugar Works.

FRESH CHIPS.

Date.	Degrees cor. Brix.	Sucrose.	Glucose.	Solids not sugar.	Glucose ratio.	Solid not sugar ratio.	Coeffi- cient of purity.	Inver- sion.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>				<i>Per cent.</i>
Sept. 10 to 20	16.58	10.02	2.62	3.94	26.15	33.32	60.43	.....
Sept. 20 to Oct. 15	16.09	10.38	1.81	3.90	17.44	37.57	64.51	.....
Oct. 15 to 30	16.67	11.18	1.84	3.65	16.45	32.64	67.67	.....
Averages of season ..	16.32	10.536	1.92	3.864	18.22	36.67	64.56	.....

DIFFUSION JUICES.

Sept. 4 to 20	8.94	5.62	1.05	2.27	18.68	25.39	62.8	.....
Sept. 20 to Oct. 15	12.77	8.56	1.69	2.52	19.74	29.44	68.5	.3331
Oct. 15 to 30	14.03	9.90	1.70	2.57	17.18	23.53	70.5	.2057
Averages of season ..	12.30	8.30	1.61	2.39	19.39	28.79	67.56	.....

CLARIFIED JUICES.

Sept. 4 to 20	9.53	6.10	1.31	2.12	21.47	22.24	64.00	.....
Sept. 20 to Oct. 15	13.77	9.44	1.45	2.88	15.36	30.51	68.56	.....
Oct. 15 to 30	14.89	10.13	1.57	3.19	15.49	30.50	68.03	.....
Averages of season ..	13.23	8.96	1.49	2.78	16.64	30.69	67.72	.....

EXHAUSTED CHIPS.

Date.	Sucrose.	Dilution.	Extraction.	Average tempera- ture of discharged juice, 10- inch cell.	Variation of tempera- ture.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>° C.</i>	<i>° C.</i>
Sept. 10 to 20	1.50	84.35	85.03	52	68 to 40
Sept. 20 to Oct. 15	1.07	25.98	89.69	49	58 to 45
Oct. 15 to 30	1.69	18.82	84.88	49	54 to 44
Averages of season ..	1.38	32.68	87.00	50	68 to 44

Battery work at Topeka Sugar Factory.

Study of middle period of season.

Date.	Character of chip.	Temperature of discharging cell.	Degrees cor. Brix, shown by battery report.	De. grees cor. Brix, chip juice.	Dilution.	Extraction.	Sucrose in exhausted chips.	No. cells worked	Time lost.	No. cells.
		°C			Per ct.	Per ct.	Per ct.		Hrs.	Per hr.
Sept. 21	Fair	51	8.26	16.87	104.25	90.20	1.05	54	9.00	3.60
Sept. 23	Poor	47	10.46	17.80	70.07	84.95	1.63	71	9.50	4.89
Sept. 24	Fair	52	12.38	17.28	39.61	88.50	.74	25	8.25	1.62
Sept. 26	Poor	46	12.92	15.42	19.35	84.23	1.20	64	5.75	3.51
Sept. 27	Good	49	14.46	18.19	25.72	92.17	.70	70	5.00	3.68
Sept. 29	do	47	12.76	16.57	30.00	93.00	.69	61	2.50	2.83
Sept. 30	do	47	15.11	16.32	8.00	89.30	1.17	64	4.00	3.20
Oct. 1	Fair	48	13.80	16.18	17.24	89.58	1.11	46	9.50	3.17
Oct. 2	do	48	13.04	15.40	15.79	90.17	1.07	52	9.50	3.58
Oct. 3	do	60	11.88				.54	23		
Oct. 4	do	49	14.19	17.81	25.51	87.67	1.28	38	13.50	3.62
Oct. 5	Good	51	14.45	15.53*	7.26*	94.10*	.57	77	1.75	3.01
Oct. 6	do	52	12.33			87.00	1.17	43	8.00	2.75
Oct. 7	do	48	12.63	15.50	22.72	95.09	.46	71	3.50	3.30
Oct. 8	do	50	14.48	16.91	16.77	90.20	.93	77	5.00	4.05
Oct. 9	do	50	14.20	16.56	16.62	90.80	.88	69	1.50	3.07
Oct. 11	Fair	47	13.43	15.97	11.46	86.33	1.43	81	2.50	3.77
Oct. 12	Poor	48	13.55	15.66	15.57	80.57	1.92	41	13.50	3.62
Oct. 13	Good	52	12.44	15.98	28.45	90.97	.96	74	4.00	3.70
Oct. 14	Fair	50	13.07	14.39	10.17	85.52	1.37	84	5.00	4.42
Oct. 15	do	51	13.37	16.18	20.26	87.53	1.41	104	4.00	5.20
Totals and means		50	13.01	16.31	25.59	88.89	1.01	1,289	135.25	3.49
Maxima		60	15.11	18.19	104.25	95.09	1.92	104	13.50	5.20
Minima		46	8.26	14.39	7.26*	80.57	.54	23	1.50	1.62

Time lost, hours:

Per cent.=26.78 total loss.

— 8.33 per cent. loss or 2 hours out of 24.

=18.45 loss on account of works.

OPERATIONS AT CONWAY SPRINGS, KANSAS.

The large factory at Conway Springs having been abandoned after two seasons of unsuccessful operation, the only work which was done at that place consisted in an attempt to make sugar in a small way by milling and open evaporation.

The results, easily predicted, only serve as another illustration of the futility of attempting sorghum sugar manufacture without any of the appliances or conditions necessary to success.

The promoters of the enterprise, however, desiring to have some chemical work done, a chemist was employed for the season. Chemical work was commenced on the 25th of September, and practically concluded on the 25th of October. During this time the mill was in operation only at irregular intervals, and there was found a total lack of proper preparation. The whole process, in fact, was characterized by unscientific methods.

The cane showed a great deterioration from the quality produced in the preceding years, but the cause of this inferiority is not clearly evident.

Forty-two analyses of samples of cane from the field showed in the juice the following percentages :

Total solids	per cent...	18.1
Sucrose	do	10.4
Glucose	do	4.4
Purity .....	.....	57.5

Twenty-four samples of juices taken from the mill during the period it was in operation showed the following numbers :

Total solids	per cent..	16.5
Sucrose	do	9.5
Glucose	do	4.5
Purity .....	.....	57.6

The unfitness of these canes for sugar making purposes is at once evident. As a natural result of the poor quality of the raw material and inadequate methods of manufacture pursued no sugar at all was produced, and even the molasses made was of a very inferior quality.

The chemical work at Conway Springs was conducted by Mr. M. C. Mechem. Following are the results in detail :

Average samples of canes from fields.

No.	Date.	Solids.	Sucrose.	Glucose.	Purity.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		
1	Sept. 25	17.0	11.5	.....	65.0	Green orange.
2	Sept. 25	21.4	3.8	.....	17.0	Amber, overripe, cut 4 days.
3	Sept. 25	24.8	1.8	.....	7.4	Do.
4	Sept. 25	15.7	10.3	.....	67.0	Green orange.
5	Sept. 25	24.1	14.7	.....	60.9	Amber.
6	Sept. 25	19.1	13.9	.....	70.8	Orange.
7	Sept. 25	16.5	11.0	.....	63.0	Do.
8	Oct. 3 (?)	15.6	9.6	.....	61.3	Orange, half ripe.
9	.....	17.8	11.8	.....	67.0	Do.
10	.....	17.5	12.2	.....	69.7	Honey dew, ripe.
11	.....	18.1	13.1	.....	72.1	Orange, half ripe.
12	.....	13.2	6.4	.....	48.8	Orange, green.
13	.....	15.1	9.9	.....	65.0	Do.
14	.....	17.3	10.4	3.30	60.0	Orange, half ripe.
15	.....	17.8	12.0	2.10	67.4	Orange, green.
16	.....	15.3	9.4	2.70	61.4	Do.
17	.....	15.5	9.7	2.60	62.4	Do.
18	.....	.....	.....	.....	.....	.....
19	.....	.....	.....	.....	.....	.....
20	.....	18.5	13.1	2.8	70.8	Orange, half ripe.
21	.....	15.7	9.2	6.5	58.5	Orange, green.
22	.....	16.8	11.5	3.7	68.3	Orange, half ripe.
23	.....	21.8	14.8	3.8	67.8	Orange, ripe.
24	.....	18.5	8.6	7.1	46.4	Orange, half ripe, cut 3 days.
25	.....	18.0	13.4	2.5	74.4	Orange, just cut.
26	.....	17.5	12.4	2.9	70.8	Do.
27	.....	16.5	11.0	3.3	66.6	Do.
28	.....	15.3	9.8	2.9	62.0	Orange, green.
29	.....	24.6	8.0	10.0	32.5	Same as No. 23, had been cut 24 hours.
30	.....	22.5	7.5	10.5	33.3	Orange, half ripe, cut 4 days.
31	.....	15.1	9.3	4.3	61.5	Orange, green, just cut.
32	.....	16.1	10.5	4.1	65.2	Do.
33	.....	17.7	11.3	3.3	63.8	Do.
34	.....	15.7	8.8	3.8	56.0	Do.
35	.....	24.6	8.2	10.8	33.3	Same as 23 and 29, cut 48 hours.
36	.....	22.4	4.5	12.5	20.0	Orange, ripe, cut 5 days.
37	.....	15.8	10.7	3.1	67.7	Orange, green, just cut.
38	.....	18.1	13.4	2.2	74.0	Orange, ripe, just cut.
39	.....	18.0	14.5	1.5	80.5	Do.
40	Oct. 19	16.9	11.5	2.1	68.0	Orange, half ripe.
41	.....	15.7	10.7	3.8	68.1	Orange, green.
42	.....	17.6	13.0	1.4	73.8	Orange.
Means		18.1	10.4	4.4	57.5	

Average sample of mill juices, Conway Springs.

No.	Date.	Solids.	Sucrose.	Glucose.	Purity.	Remarks.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		
1	Oct. 19	16.6	11.2	2.1	67.4	
2	Oct. 19	15.6	9.8	2.8	63.8	
3	Oct. 19	16.4	8.7	2.0	34.7	
4	Oct. 19	15.3	8.4	3.1	54.9	
5	.....	16.5	10.5	4.1	63.6	
6	.....	15.9	10.4	3.0	65.5	
7	.....	17.2	10.9	4.0	63.3	
8	.....	17.3	10.7	4.3	61.8	
9	.....	18.0	11.5	3.0	63.3	
10	.....	13.1	9.7	3.9	74.0	
11	.....	15.8	9.7	5.4	61.3	
12	.....	14.8	9.4	4.4	63.5	
13	.....	16.3	10.7	4.2	66.3	
14	.....	16.5	10.7	3.7	64.8	
15	.....	16.2	9.7	6.1	60.0	
16	.....	13.5	8.0	4.1	69.2	
17	.....	19.4	8.2	10.0	42.2	Cut 6 days and piled in field.
18	.....	18.1	10.0	7.1	55.2	Cut 7 days and piled in field.
19	.....	21.0	10.0	9.0	47.6	Cut 8 days and piled in field.
20	.....	18.5	9.5	4.1	51.5	Cut 9 days and piled in field.
21	.....	18.0	7.6	5.3	42.2	Cut 10 days and piled in field.
22	.....	17.6	6.0	6.2	34.0	Cut 1 day after frost. †
23	.....	14.8	7.5	3.3	50.6	Cut 2 days after frost.
24	.....	14.2	8.5	3.4	59.8	Frosted twice.
Means		16.5	9.5	4.5	57.6	

Average samples of clarified juice, Conway Springs.

Number.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
1.....	17.8	10.7	3.8	60.1
2.....	17.7	9.0	2.5	50.8
3.....	18.4	10.7	4.1	58.2
4.....	18.9	12.1	5.0	64.0
5.....	18.8	10.0	6.1	50.3
6.....	18.3	9.7	5.4	54.1
7.....	16.2	10.2	4.1	63.0
8.....	16.4	9.0	4.7	54.8
9.....	22.0	5.5	7.5	25.0
10.....	18.9	6.4	10.5	33.8
11.....	16.3	8.5	3.0	62.1
12.....	21.2	5.8	3.1	27.3
13.....	18.1	7.7	4.2	42.5
14.....	15.1	8.1	3.4	53.5
Means ..	18.2	8.8	4.8	48.4

Average samples of molasses, Conway Springs.

Number.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
1.....	72.5	46.2	13.69	57.3
2.....	84.8	48.0	12.50	56.6
3.....	90.4	52.6	15.30	58.2
4.....	87.2	32.8	31.00	37.61
Means ..	83.7	44.9	18.12	.....

OPERATIONS AT MEDICINE LODGE, KANSAS.

The chemical work at Medicine Lodge was in charge of Mr. T. F. Sanborn, assisted by Mr. E. G. Runyan.

Manufacturing operations at Medicine Lodge commenced on the 18th of August and continued until the end of October. The machinery in use last year had been thoroughly overhauled and placed in excellent working order. No delays of any consequence were experienced in working the apparatus, and, for the first time in the history of the manufacture of sorghum sugar, the losses due to delays were reduced to a minimum.

The crop of sorghum cane was grown in a season of great drought, which prevented the corn crop from maturing. The evil effects of the drought were felt also on the cane, but in spite of it a crop of considerable magnitude was produced. On the 25th of August the long period of drought and hot winds was broken by copious rains, and from that time until the end of the manufacturing season frequent rains fell. The cane in the fields readily ripened after the rains, and many fields which were considered worthless redeemed themselves and produced considerable quantities of merchantable cane. The high red loam of the uplands produced a better crop than the low bottom lands, both in quantity and quality. In addition to this the first frost affected only the bottom lands, and the cane on the uplands had fully three week's longer season on this account than the cane on the low lands.

The results of the mean analyses of the cane chips entering the battery for the season show the following numbers :

In the juice.

Total solids	per cent..	18.29
Sucrose	do	12.62
Glucose	do	2.24
Purity		69.86

The exhausted chips contained 0.81 per cent sucrose ; the mean polarization of the first sugars made was 91.8 and of the second sugars made 91.2. The mean percentage of sugar in the cane extracted for the whole season was 93.6. The mean percentage of marc or fiber in the cane was 12.2 per cent.

Nine hundred and forty-one miscellaneous analyses of the cane from farmers in different parts of the county were made with the following mean results :

In the juice.

Total solids	per cent..	19.83
Sucrose	do	15.12
Glucose	do	2.21
Purity		71.01

The summary of the season's work will give a fair idea of what was accomplished :

Working days.....	35
Clean cane worked..... tons..	3, 957
First sugar obtained, per ton of clean cane pounds..	101. 1
Second sugar obtained, per ton of clean cane. ....do....	22. 5
Total yield, per ton of clean cane.....do....	123. 6
Sugar obtained, based on total amount in cane ... per ct..	51. 4
Molasses made, per ton of clean cane.....gallons..	13. 8
Total weight of sugar made.....pounds..	489, 357

Summary of work on early cane.

Cane diffused.....	tons..	1, 249. 635
Cane diffused	pounds..	2, 499, 270
Sugar obtained :		
Firsts	pounds..	103, 110
Seconds.....	do....	19, 980
Sugar obtained total.....	pounds..	123, 090
First sugar, per ton of cane	pounds..	82. 5
Second sugar, per ton of cane	pounds..	16
Total sugar, per ton of cane.....	pounds..	98. 5
Molasses obtained.....	gallons..	12, 470
Molasses obtained.....	pounds..	149, 640
Molasses obtained, per ton of cane.....	gallons..	9. 9
Molasses obtained, per ton of cane	pounds..	118. 8
Molasses obtained, per 1,000 pounds sugar.....	gallons..	101. 6
Molasses obtained, per 1,000 pounds sugar	pounds..	1, 219. 2

Summary of work on late cane.

Number of working days	26
Clean cane diffused	tons.. 2, 707. 552
Clean cane diffused	pounds.. 5, 415, 104
Per cent juice in clean cane	87. 8
Sucrose in clean cane.....	pounds.. 651, 708
Glucose in clean cane.....	do.... 103, 720
Available sugar in clean cane (approximate)....	do.... 496, 128
Sugar obtained per ton of clean cane:	
Firsts	pounds.. 109. 6
Seconds	do.... 25. 7
Total	pounds.. 135. 3
Sugar obtained :	
Firsts	296, 926
Seconds	69, 341
Total	pounds.. 366, 267
Sugar obtained, per cent sucrose in cane	56. 2
Molasses obtained.....	gallons.. 42, 162
Molasses obtained, per ton of clean cane	do.... 15. 4
Molasses obtained, per ton of clean cane	pounds.. 184. 4
Molasses obtained, per 1,000 pounds sugar.....	do.... 1, 368. 5
Sucrose lost in exhaust chips.....	pounds.. 44, 854

Sucrose inverted in battery.....pounds..	6, 146
Mechanical loss and inversion not noted.....do....	43, 359
Total loss .....do....	94, 359
Sucrose in molasses .....pounds..	191, 082
Total loss, per cent. sucrose obtained	25. 8
Total loss, per ton of clean cane	34. 8
Total loss, per cent of sucrose in cane.....	14. 4

Summary of work for season.

Number of working days.....	35
Clean cane diffused.....tons..	3, 957. 187
Clean cane diffused .....pounds..	7, 914, 374
Topped cane diffused.....tons..	4, 767. 695
Topped cane diffused .....pounds..	9, 535, 390
Per cent leaves and trash in topped cane	17
Per cent juice in clean cane	87. 8
Sucrose in cane .....pounds..	876, 521
Glucose in cane.....do....	155, 279
Available sugar in cane (approximate) .....do....	643, 154
Sugar obtained, per ton of clean cane :	
Firsts.....pounds..	101. 1
Seconds .....do....	22. 5
Total .....pounds..	123. 6
Sugar obtained per ton of topped cane :	
Firsts.....pounds..	83. 9
Seconds .....do....	18. 7
Total .....pounds..	102. 6
Commercial sugar obtained :	
Firsts .....pounds..	400, 036
Seconds .....do....	89, 321
Total .....pounds..	489, 357
Sugar obtained, per cent of sucrose in cane.....	55. 9
Molasses obtained.....gallons..	54, 632
Molasses obtained, per ton of clean cane.....do....	13. 8
Molasses obtained, per ton of clean cane.....pounds..	165. 6
Molasses, obtained, per 1,000 pounds sugar.....do....	1, 332
Losses :	
Sucrose lost in exhausted chips.....pounds..	64, 106
Sucrose inverted in battery .....do....	9, 219
Mechanical loss and inversion not noted....do....	63, 538
Total loss for season	136, 863
Sucrose in molasses .....pounds..	250, 301
Total loss, per cent of sucrose obtained	27. 9
Total loss, per ton of clean cane.....	34. 6
Total loss, per ton of topped cane.....	28. 6
Total loss, per cent of sucrose in cane.....	15. 6
Cane harvested .....acres..	1, 200

Comparison of cane grown on high and low ground—Results of 507 analyses.

	High.	Low.
Sucrose:		
Mean	15.13	12.84
Maxima	18.45	16.95
Minima	11.20	6.40
Purity:		
Mean	72.81	70.77
Maxima	84.95	80.20
Minima	58.17	58.29

The details of the analytical work are found in the following tables:

Fresh chips.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Sept. 16	18.55	11.79	2.79	63.66	Oct. 7	17.99	12.19	2.37	68.76
Sept. 17	18.14	12.31	2.34	67.47	Oct. 9	18.47	13.31	2.31	73.06
Sept. 18	18.13	11.69	2.03	64.47	Oct. 10	18.41	12.04	2.26	66.39
Sept. 19	17.80	12.76	2.09	71.69	Oct. 11	18.28	13.00	2.18	71.11
Sept. 20	18.24	11.81	2.48	64.69	Oct. 12	18.18	13.94	1.43	76.67
Sept. 25	19.10	12.27	2.39	64.24	Oct. 13	19.31	13.59	2.09	70.38
Sept. 26	18.18	13.30	2.22	73.16	Oct. 14	18.73	13.04	2.28	70.12
Sept. 27	17.77	12.06	2.11	67.86	Oct. 15	19.60	14.08	2.26	71.43
Sept. 29	17.99	11.68	2.01	65.01	Oct. 16	18.81	13.87	2.31	73.73
Sept. 30	17.94	12.04	2.20	67.32	Oct. 17	18.37	12.86	2.28	70.00
Oct. 1	17.17	10.69	2.17	64.55	Oct. 18	18.53	13.19	2.27	71.19
Oct. 2	17.84	12.89	2.24	73.35					
Oct. 3	18.31	12.69	2.23	69.31	Mean ...	18.29	12.62	2.24	69.86
Oct. 4	17.87	12.07	2.24	68.23	Maxima.	19.60	14.24	2.64	78.41
Oct. 6	18.03	14.24	2.64	78.41	Minima.	17.17	10.69	1.43	63.66

Diffusion juices.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Sept. 16	11.54	7.68	1.74	67.55	Oct. 7	10.81	7.35	1.02	67.99
Sept. 17	11.80	7.90	1.38	66.95	Oct. 9	10.09	7.00	1.00	69.37
Sept. 18	11.22	7.50	1.43	67.84	Oct. 10	10.29	7.32	1.07	71.13
Sept. 19	10.67	7.23	1.23	67.76	Oct. 11	10.09	7.32	1.09	72.54
Sept. 20	10.29	7.36	1.07	71.52	Oct. 12	10.23	7.67	.84	74.94
Sept. 25	10.19	7.21	1.09	70.75	Oct. 13	11.72	8.46	1.01	72.18
Sept. 26	10.39	7.31	1.03	70.35	Oct. 14	10.29	7.67	.93	74.34
Sept. 27	9.20	6.73	1.09	71.82	Oct. 15	10.25	7.44	1.02	72.59
Sept. 29	9.54	6.67	.86	76.29	Oct. 16	10.69	7.36	.98	67.84
Sept. 30	9.67	7.11	1.19	73.52	Oct. 17	9.60	7.02	.93	74.55
Oct. 1	10.15	6.71	1.09	66.11	Oct. 18	10.19	7.46	1.05	73.20
Oct. 2	10.93	7.37	1.04	67.43					
Oct. 3	11.45	7.12	1.08	62.09	Mean ...	10.25	7.36	1.09	67.84
Oct. 4	10.71	7.19	1.09	67.13	Maxima.	11.80	8.46	1.74	74.94
Oct. 6	11.75	7.96	1.03	65.57	Minima.	9.20	6.67	.84	62.09

Clarified juices.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Sept. 16	12.15	8.29	2.07	68.26	Oct. 7	11.25	7.66	1.14	68.09
Sept. 17	12.70	7.51	1.39	67.02	Oct. 9	10.95	7.58	1.12	69.31
Sept. 18	12.03	8.09	1.40	67.31	Oct. 10	10.59	7.42	.99	70.16
Sept. 19	9.51	6.83	1.26	67.23	Oct. 11	10.42	7.64	1.20	73.39
Sept. 20	11.04	7.88	1.07	71.75	Oct. 12	10.37	8.38	.77	80.80
Sept. 25	10.64	7.54	1.09	71.00	Oct. 13	11.55	8.61	1.05	72.02
Sept. 26	11.16	7.83	1.07	70.58	Oct. 14	10.69	7.69	.97	74.63
Sept. 27	10.61	6.42	1.09	62.02	Oct. 15	10.55	7.38	1.13	70.02
Sept. 29	10.04	6.85	.94	68.23	Oct. 16	11.09	7.45	1.06	67.83
Sept. 30	10.03	7.43	1.21	74.11	Oct. 17	10.10	7.29	1.05	72.22
Oct. 1	10.03	6.62	1.11	66.14	Oct. 18	10.89	7.84	1.19	73.41
Oct. 2	11.33	7.64	1.07	67.44					
Oct. 3	11.19	7.10	1.09	63.51	Mean ...	11.17	7.59	1.14	68.55
Oct. 4	11.05	7.39	1.22	67.00	Maxima.	12.70	8.38	2.07	80.80
Oct. 6	12.11	7.79	1.07	64.32	Minima.	9.51	6.42	.77	62.02

Semisirups.

Date.	Solids.	Sucrose.	Glucose.	Purity.	Date.	Solids.	Sucrose.	Glucose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Sept. 16	36.94	25.5	5.98	69.01	Oct. 7	39.27	27.8	4.42	69.20
Sept. 17	46.20	31.3	4.80	67.80	Oct. 9	49.53	28.3	4.30	69.90
Sept. 18	35.58	23.8	4.61	67.00	Oct. 10	34.28	25.5	4.17	74.11
Sept. 19	34.62	25.5	4.21	67.85	Oct. 12	44.62	35.2	2.99	78.88
Sept. 20	39.27	27.5	4.01	72.73	Oct. 13	43.00	31.5	4.02	73.31
Sept. 25	37.10	26.6	3.85	71.71	Oct. 14	40.03	29.6	3.98	73.92
Sept. 26	36.67	26.8	4.11	73.33	Oct. 15	38.15	27.9	4.00	73.11
Sept. 27	32.41	22.4	4.21	69.29	Oct. 16	40.17	27.7	3.97	69.21
Sept. 29	43.20	30.5	4.17	70.70	Oct. 17	36.96	27.3	4.19	73.82
Sept. 30	36.98	27.4	4.10	74.20	Oct. 18	45.70	33.8	4.03	74.07
Oct. 1	35.20	23.6	4.26	67.11					
Oct. 2	37.88	26.5	4.01	69.81	Mean ...	37.88	26.5	4.17	70.18
Oct. 3	43.30	28.4	4.19	65.21	Maxima.	46.20	35.2	5.98	78.88
Oct. 6	40.43	25.6	3.93	63.10	Minima.	32.41	22.7	2.99	63.10

Exhausted chips.

Date.	Solids.	Sucrose.	Date.	Solids.	Sucrose.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Sept. 16..	2.03	.96	Oct. 7....	1.26	.65
Sept. 17..	2.20	.56	Oct. 9....	2.01	.33
Sept. 18..	1.57	1.05	Oct. 10..	2.02	.72
Sept. 19..	1.67	1.20	Oct. 11..	1.01	.62
Sept. 20..	2.07	.99	Oct. 12..	2.17	.51
Sept. 25..	2.06	.76	Oct. 13..	1.12	.41
Sept. 26..	2.60	.78	Oct. 14..	2.12	.62
Sept. 27..	2.41	.72	Oct. 15..	1.46	.57
Sept. 29..	2.18	.92	Oct. 16..	.92	.37
Sept. 30..	2.06	1.18	Oct. 17..	1.68	.56
Oct. 1....	2.22	1.18	Oct. 18..	1.91	.72
Oct. 2....	2.26	1.04			
Oct. 3....	2.06	.93	Mean...	1.88	.81
Oct. 4....	2.21	.72	Maxima.	2.60	1.20
Oct. 6....	1.76	.76	Minima.	.92	.37

GENERAL RESULTS OF MANUFACTURING WORK.

SMALL FACTORIES.

It is to be regretted that certain hallucinations seem to constantly follow the development of the sorghum sugar industry. This Department has pointed out repeatedly the insurmountable difficulties attending the production of sorghum sugar in a small way and with crude apparatus and unscientific methods. The record of the past season at the various points where the Department was represented by its chemists tends to confirm the views in this regard so often expressed heretofore. Thus the development of this industry has had to contend not only with natural difficulties, but with the discouragement attending numerous failures, although such failures were altogether due to causes which would have resulted as badly in connection with any other industry. In some cases, as in the experiment at Conway Springs, for instance, the promoters testified to the honesty of their convictions by investing their own private funds without any public aid. While such an investment is certain to be followed by financial loss, what is far worse from a public point of view, is that it will prejudice the community against the the whole business, and prevent people from viewing in the proper light processes which really give promise of success.

It is evidently the duty of the Department to caution farmers, and to reiterate what has been so often stated, that with our present knowledge, and with the present degree of development of the sorghum cane, it is not practicable to produce sugar profitably in a small way and without an ample and suitable equipment. That a good article of table sirup can be made with moderate facilities and profitably has long been known, and I conceive it to be the duty of the Department to encourage such work as that, and to discourage in every possible way attempts to make sugar under conditions and with apparatus suitable only for the manufacture of sirup. It is unfortunate that in spite of the unsatisfactory results a glowing report has been published of the

season's work at Conway Springs, and still more unfortunate to find it copied in an influential sugar journal without any comment whatever, thus lending to it an air of authority which it is feared may prove to some extent injurious.

If the alcohol method of treating sirups should prove to be a success, it might then be profitable in some localities to make a thick sirup in some small way for delivery to a central factory. Such a method might be advisable in cases where cane would otherwise have to be hauled a long distance to the central factory. These possibilities, however, are still in the future, and do not call for discussion at the present time.

LARGE FACTORIES.

After so many years of experiment and endeavor no really first-class factory has yet been constructed for making sorghum sugar. The large factories which have been operated have been always hastily and often imperfectly constructed, and, as a result, their operations have been attended with costly and disastrous delays.

The reports of the chemists from all these factories, with one exception, have contained accounts of these disasters, but so often have they been recorded, that to avoid a wearisome iteration in this bulletin they have been mostly omitted.

For economical purposes, the capacity of a factory must be definitely known, and it must be ready to do its daily work with regularity. This accomplished, a proper amount of raw material can be furnished each day and the cost of operation be reduced to a minimum. Each part of the house must be capable of doing its full share of the work, since the daily capacity of a factory is that of its weakest part.

Through costly and often ruinous experiences the sorghum sugar industry has slowly advanced, until now the soil and climatic conditions favorable to the growth of the plant are clearly understood, and the mechanical appliances necessary to its successful manufacture well established. Not in a remodeling of old factories, but in new ones, built with ample time and capital, and operated under skilled supervision, will future successes be obtained.

FUNCTIONS OF EXPERIMENTAL WORK.

One of the chief causes of delay in the advancement of the sorghum-sugar industry has been due to a misapprehension of the true functions of experimental work. There has been a constant demand that the experiments of the Department should be conducted on a manufacturing scale and in connection with a factory in active operation.

The difficulties which attend such a connection of experiment with business can only be appreciated by one who has been compelled by the exigencies of the public service to endure their burdens.

The fundamental requirement of experimental work is the ability to control it and change its conditions. This power is wholly wanting during the course of a sugar-manufacturing campaign. All energies are then enlisted in the work of saving the crop, and the requirements of experiment receive little attention.

Experimental work should be wholly freed from all entangling manufacturing alliances. Otherwise, instead of leading to sound and lasting results, it usually becomes a factory farce.

There is yet much experimental work to do in establishing a sugar industry in this country, and to attain the highest results it must be free from all such impediments to its thorough prosecution.

RECORD OF WORK IN CANE IMPROVEMENT.

CULTURE EXPERIMENTS AT MEDICINE LODGE, KANSAS.

Interesting observations were made on the effect of the drought upon the different varieties of cane. The Early Orange and Link's Hybrid gave about the same tonnage under similar conditions and also had about the same content of sugar. If there was any advantage it was in favor of the Link's Hybrid. The varieties Undendebule and Honey Dew gave disappointing results; the tonnage was light, sucrose and purity low, and the cane rapidly deteriorated after a light frost. A new variety of cane, which may be called, provisionally, Medicine Lodge Orange, made a splendid showing. The seed head of this variety is small, compact, and does not spread or open on reaching maturity. The stalk is perfectly formed and resembles very nearly that of the Early Orange, from which it can be distinguished only by its earlier ripening. It contains a high percentage of sucrose, low glucose, and endures a dry season remarkably well. It ripens in from 90 to 100 days from the time of planting. It is also hardy and does not deteriorate rapidly after frosts.

The Black African was one of the best varieties tested during the season. This variety not only has high sucrose and purity, and low glucose, but is a large cane and endures drought well. Its tonnage was nearly double that of the other varieties and it maintained its high percentage of sucrose longer than any other variety tried.

As a result of the agricultural experience of the season, it seems best to plant only the early maturing varieties on the lowlands while the late maturing varieties should be planted on the uplands.

In regard to the analyses of the Link's Hybrid variety the means of 413 analyses show the following numbers:

In the juice.

Total solids.....	per cent..	19.72
Sucrose	do.....	13.59
Glucose	do.....	1.85
Purity.....		70.00

Four hundred and sixty-two analyses of the Early Orange during the season show the following data :

In the juice.

Total solids	per cent..	20.20
Sucrose	do....	13.20
Glucose	do....	1.96
Purity		65.24

Eighty-seven analyses of the Medicine Lodge Orange gave the following data :

In the juice.

Total solids	per cent..	20.18
Sucrose	do....	15.60
Glucose	do....	1.87
Purity		78.82

Thirteen analyses of the Undendebule gave the following data :

In the juice.

Total solids	per cent..	18.80
Sucrose	do....	12.45
Purity		65.93

Thirteen analyses of Honey Dew showed for the season the following results :

In the juice.

Total solids	per cent..	17.42
Sucrose	do....	11.43
Glucose	do....	2.98
Purity		64.19

Following are the mean analyses of the Black African for the month of November :

In the juice.

Total solids	per cent..	19.88
Sucrose	do....	13.90
Glucose	do....	2.04
Purity		71.98

Samples of cane were taken from 1,973 loads brought to the factory and examined with the following mean results :

In the juice.

Total solids	per cent..	19.31
Sucrose	do....	13.30
Purity		69.14

CULTURE EXPERIMENTS AT STERLING, KANSAS.

I was directed to continue at Sterling the culture work in sorghum which had given such good results in former years.

The personal oversight of the work was again committed to Mr. A. A. Denton, whose sound judgment and great industry and enthusiasm had already been so fruitful of good to the sorghum-sugar industry. Mr. Denton was instructed to continue the line of investigations pursued in former years, and to note all facts which appeared to be of any value to the further progress of the industry. The details of the work were left entirely to his own supervision.

Dr. C. A. Crampton, who had rendered such valuable services to the industry in conjunction with Mr. Denton in former years, having retired from the Department to enter the scientific service of the Treasury Department, the chemical part of the work was placed in charge of Mr. K. P. McElroy and a competent corps of assistants.

The substance of the report following was prepared jointly by Messrs. Denton and McElroy, and I have arranged it with only such changes as the demands of brevity and the results of contemporaneous investigations have required :

The experimental work of the Department at Sterling was continued during the year 1890 on the same general lines of work as those followed in previous years. The whole year was exceptionally dry. Planting was commenced on the 1st of May and finished on the 23d. Before the last of the planting was completed the ground had become so dry that the seed of the last lots planted remained for a long time in the ground without germinating. Not only did this cause a late maturity of the canes whose germination had been deferred, but also produced an uneven ripening of all the plots thus affected. Some of the seed which germinated as soon as planted produced canes ripening long before those from the delayed germination. Planting was done by hand and the seed covered by a hoe.

The land varied widely in quality from fairly fertile spots to barren sandy knolls. Much of it had not been in cultivation for several years, and part of it had been in sorghum for many years. In addition to these disadvantages of soil and season, a severe frost on the 13th of September killed all the cane in the greater part of the experimental plots. This frost was almost a month earlier than the average of the locality. After the frost the working force of the station was brought down two-thirds, and the total amount of work done was probably only about one-third what it would have been had the frost been delayed for another month. In many of the plots, however, the analyses were kept up for some time after the frost, selecting for this purpose stalks here and there which still showed green leaves. In some cases the canes

which had been frostbitten rapidly deterioriated, and in no case did they improve, but in some instances they remained quite stationary in quality for a considerable length of time. It was noticed in many cases that the canes retained their sugar content in quite a constant manner for five weeks after the frost had destroyed nearly all the leaves. The comparison of varieties under such circumstances must be more or less unreliable, and hence the analytical work of the station is not as indicative in its results as it was during previous years. The experimental plots occupied in all about 165 acres. The different plots were sowed in plots 25 feet wide, leaving about 25 feet between them to avoid mixing. This is probably not a sufficient distance, but on account of the large number of plots with which it was desired to experiment it was not possible to plant them farther apart without extending to undue proportions the total area under cultivation.

One hundred and twenty-seven plots were planted with seeds from foreign countries, received through the Department of State in response to a request from the Department of Agriculture. Two hundred plots were planted with seed selected at the station last year by the analyses of single canes. Twenty-six plots were planted from seeds which were received from Dr. Peter Collier, director of the Experiment Station at Geneva, New York. Four hundred and fifty-five plots were planted with seeds from canes which showed evidences of being crosses of Link's Hybrid and Early Amber. Each of these plots was planted with seed from a single head, and were grown in the hope of finding among them canes showing new and desirable qualities. Some of these plots gave remarkably fine canes of new types having from 14 to 16 per cent of sugar, while others were inferior in every respect to each of the parent forms. In all, twenty of these plots seemed sufficiently good to justify preservation, and the seed was saved from them for future growth.

All the one hundred and fifty-three plots planted with foreign seed, including two varieties, unnamed, from Australia, produced fine canes of good quality.

Of the various crosses first selected in 1888, planted in 1889 and again in 1890, several having proved unusually good during the three years of trial, will be retained for further experiment. Most of these new varieties are now well established and uniform in their characteristics, but there are some which still show a persistent tendency to reversion. Special data which were obtained with the Colman cane and with numbers 160, 161, and 289, are of such a character as to fully justify the whole of the labor which has been expended by the Department at the station in the development of new varieties from crosses. These four varieties possess qualities for sugar-making superior to all other known varieties of sorghum, and these characteristics have been secured by careful attention to scientific principles of selection and propagation which have been practiced at Sterling from the first.

There is still opportunity for a large amount of judicious work in selecting from varying seedling canes, having juices of greater purity; for there are wide differences in this respect, and it will require several years more to develop among them characteristics sufficiently uniform to justify their selection as sugar-producing plants.

Many varieties which had given good results in previous years were planted in a large number of plots in different soils and at various times in order to determine their average value. The stand of cane was almost perfect except where destroyed by drifting sand. The seeds selected at the station have often shown a vitality of 98 per cent at the time of planting. With such seed and due care in sowing, it would seem possible, so far as the experimental work has shown, to have a good stand of cane without either thinning or replanting. Neither was done this year. No fertilizers were used and no suckers nor offshoots removed. With the exception of small plots, which were hoed twice, the cultivation was such as any careful farmer would give his crop. In such hot and dry seasons as this was there seems no doubt that deep and close cultivation after the canes are large injures them. On the other hand, frequent and shallow cultivation, even after the canes are well grown, favor their development on principles of soil physics which are well understood.

The yield of cane per acre was not nearly so large this year as in the season of 1889, but was better than in 1888. In general all the varieties which have been subjected to careful selection showed a larger percentage of available sugar in the juice than any other of the previous years. Another point mentioned is that the character of the juices in the sorghum appears to vary less with the season than does the yield of cane. As an instance of this characteristic, developed by the experiments, we may cite the variety of cane known as 161. In 1889 seventeen analyses of this variety were made, extending from September 4 to October 26. The average percentages given were as follows:

Sucrose	per cent..	13.24
Reducing sugar	do.....	.45
Solids not sugar	do.....	3.56
Purity	do.....	76.75

In 1890 twelve analyses of the same variety were made, extending from August 12 to October 21, showing the following mean percentages:

Sucrose	per cent..	14.81
Glucose	do.....	.69
Solids not sugar	do.....	3.77
Purity	do.....	76.85

One of the most marked effects of selection, as practiced at Sterling, has been manifested in the earlier maturing of the cane. Some of the different varieties grown during the past year ripened two or three weeks earlier than was the case with the canes from similar but unselected seed.

Judging from the work already done sorghum cane may be developed in any particular direction by continuous selection of the qualities desired. If, for instance, a high sugar content be desirable, by continued selection for high sugar only this property of the cane may be made persistent, and the same is true of low glucose or low non-sugars.

The work of the station during the year comprised 2,500 analyses of average samples of sorghum, in large quantities, taken from the plots, and about 9,000 polarizations of the juices of single selected canes. Twelve thousand selected seed heads from the best varieties were wrapped separately and descriptive tags attached to them for the purpose of continuing the work, not only at the station, but by distributing these seed heads to those interested in such researches. By planting a single seed head and saving all the seed produced therefrom a very large field of cane can be produced from each of these 12,000 heads in 1892. In other words, from these 12,000 selections it would be possible to produce seed enough to plant all the sorghum cane which will be required by all the factories in the United States in 1892. These 12,000 heads have been divided into four classes. Those coming from canes which give a juice of from 80 to 85 per cent. purity, irrespective of sugar content, were placed in the first class; those having a purity of 75 to 80 in the second, and those from 70 to 75 in the third class, and the whole of the remainder in the fourth class.

The seed selections were taken from the following varieties: Early Amber, Undendebtle (Nos. 1 and 2), Colman cane (cross of Orange and Amber), Folger's Early, Planters' Friend, Early Orange, Link's Hybrid, No. 160, No. 161, No. 110, No. 112, No. 208, No. 244, No. 289, and No. 350.

The method of making selections may not be devoid of general interest. The method pursued at Sterling was as follows:

Many thousands of canes of the particular kinds selected are run separately through hand mills and the juice from each one put in a tin can. These juices are then roughly tested by a hydrometer, giving readings representing the percentage of total solids contained in them. If this reading is below a certain fixed standard the seed head from this cane is at once rejected, the standard of the juice being kept high enough to insure a rejection of the majority of the canes. If the first reading is satisfactory, the can and the seed head of the cane furnishing the juice therein receive a number. For instance, in the variety No. 112, 765 canes were found which came up to the required standard. These were again assorted by subjecting them to analysis and 185 samples were found to contain over 15 per cent of sugar. These seed heads were then saved and all the others from the variety rejected. From those which were saved another selection was made on the purity of the juice and 121 were found to have purities ranging from 75 to 80. These seed heads were preserved and all the others rejected. Thus of the many thousands of the canes of No. 112 submitted for examination

only 121 seed heads were saved to distribute for planting next spring. With the force at the command of the station it was possible to test 3,000 canes per day. Of course it is not expected that canes showing a high percentage of sugar, say 18 per cent in the juice, will give seed which will on planting give a cane uniformly possessing this high quality. Were this true it would be possible to permanently secure and perpetuate each accidental variation showing a high percentage.

Nevertheless, it is true that seed selected in this way has a tendency to produce a larger number of high-testing canes than before, and thus by continued selection it is possible to develop finally a permanent type showing a decided increase in sugar-producing power.

It must also be taken into consideration that in cases of seed selection the development of the particular varieties of cane would be largely influenced by the environment, that is, by the soil and climate; hence it is illogical to suppose that seed which has been selected in this way and permanently established at Sterling will do equally as well in a soil and climate radically different. It is the object of the Department in this work not to select and establish varieties which will do equally well in all parts of the United States, but to illustrate the methods of establishing varieties in one particular locality, so that the particular variety of cane which is suitable to any one locality may be speedily and scientifically established by selection in other places. In many cases the seeds which have been sent from Sterling, and which continue to give there the best results, have produced canes of much inferior quality in Louisiana and Mississippi, as will be seen by data given from those localities in another place. After 3 years of study of all the varieties of sorghum which could be obtained, amounting in all to nearly 1,000 it does not seem premature to give a list of those which may be called the best. It must be understood, however, that this list is for a soil and climate similar to those in western and central Kansas, and it can not be regarded as being absolutely correct for other and widely different localities.

From the results already obtained Early Amber will be suitable for earliest planting and manufacture, or for very late planting when such is unavoidable. Earlier maturing varieties than Amber have been studied, but none of them can yet be recommended. Folger's Early has improved by selection, and No. 160 and No. 161 ripen soon after Amber and are much superior to it in many respects. Undendebule, Colman, and the well-known Link's Hybrid complete the list. To these may also be added Orange cane and its different varieties, which have proved so successful for manufacture, but which did not deport themselves as well under selection as the varieties mentioned. With the exception of Early Amber, all of these can be recommended in respect of high sugar content, good purity, and persistency of type. Folger's Early has a relatively high glucose content, but the purity is about the same as that of the others. Link's Hybrid is somewhat later in matur-

ing, and has a tall slender stalk, which is liable to be blown down. This latter defect it shares with Nos. 160 and 161.

It is hoped that in the course of a year or two No. 161 can be hastened enough in maturing to take the place of Amber. The belief is entertained that these varieties, excepting Amber, are now superior to those commonly grown for sugar-making, but selection on the lines already explained will probably result in considerable further improvement.

Hitherto the work of selection has been carried on mainly in the direction of high sugar and low glucose percentages, and in this respect its success has been most gratifying. In the future it seems evident that more particular attention must be paid to the purity of the juice, unless indeed Congress should see fit to permit the introduction of the process for making sorghum sugar by removing the gummy matters, which is proposed in another part of this report.

Unless this can be done the greatest hope of the success of the sorghum-sugar industry lies in the direction of securing a juice of high purity and especially one low in the organic matters not sugar. It would be better, therefore, in this respect to base at least one line of selection in this direction, so as to eliminate as far as possible the gummy matters in the cane. The average purity of the juices of the sorghum which have been manufactured so far is not much, if any, above 65, while with sugar cane it is about 80, and with the sugar beet even higher. Of the varieties already selected and established the Colman and No. 161 gave the best results in regard to purity, the number expressing the purity varying between 75 and 80. The importance of having a pure juice will be at once realized when it is known that the amount of sugar which is secured from a given weight of cane does not depend solely upon the content of sugar in the juice, but upon the amount of this sugar which the gummy and other uncrystallizable bodies in the juice will allow to crystallize. This was well illustrated in the work of the Department at Fort Scott, Kansas, in 1886. From sorghum cane the juice of which averaged 7.7 per cent. sucrose and less than 60 purity only 21.5 pounds of commercial sugar per ton of clean cane were made, while from sugar cane sent from Louisiana containing 10.45 per cent. of sugar and having a purity of 73, and worked by precisely the same processes and under the same control, 144 pounds of sugar were made per ton.

It appears true of sorghum juices that the nonsugars, consisting of the glucose and solids not sugar, taken together, may be in all about 4 to 5½ per cent. of the juice. It has been shown by the 3 years' selection at Sterling that the glucose percentage can be reduced to a point at which it may be practically neglected, viz., to about one-half of 1 per cent. The selection for the purpose of reducing the organic bodies not sugar has not been carried far enough to determine whether or not similar success can be expected. At the present, however, it

appears that there is a kind of reciprocity existing between the glucose and solids not sugar, so that as one is increased the other is diminished, the sum thus remaining about a constant quantity. As a rule the varieties which have a low glucose content have a high content of organic solids not sugar, and the reverse is true. If this should be the correct view, it would make the problem of selection a more difficult one, and the wiser plan would be to pursue it in the direction of reducing the organic solids not sugar and increasing the glucose, provided the manufacture of sugar is to be carried on as it now is; while if the alcohol process for the separation of the organic solids in sugar should come into use, then the wiser plan would be to pursue the selection with reference to diminishing the glucose to the least possible degree. The separation of the organic bodies not sugar by alcohol would leave a juice of remarkable purity and capable of yielding the maximum percentage of crystallizable sugar. It is highly probable, however, that all the nonsugars may finally be much reduced in amount by continued selection.

The results of the station work show that Early Amber, Folger's Early, and the various varieties of Orange have comparatively high glucose, and, as a rule, low percentages of solids not sugar. This accounts for the fact that in practice the Orange, although having a high percentage of glucose, has given uniformly good results. On the other hand, Undendebule, Colman cane, No. 161, Sorghum Bicolor, and Link's Hybrid show generally low percentages of glucose and high percentages of organic solids not sugar.

In general, therefore, it may be said that the lines of selection as indicated above will depend upon the method of manufacture to be pursued. If the method remains as it is, then without any question the direction of the lines of selection should be toward securing a juice of greater purity, even should the sucrose content itself suffer. It is far better for the manufacturer to have a sorghum juice containing 12 to 13 per cent. of sugar in the juice and a purity of 85 than to have one from 16 to 18 per cent. sugar in the juice with a purity of 65.

I have already said that the cause of a poor yield of sugar in sorghum of high polarization is due to the presence of some form of carbohydrate or other organic body exercising a higher melassigenic power than invert sugar or any form of levulose or dextrose, and the results of the research carried on in the laboratory during the past 18 months have disclosed to us the exact nature of this body, and also revealed the method of separating it as indicated in another portion of this report.

Mr. John Dymond and Dr. W. C. Stubbs estimate that a fair average analysis of Louisiana sugar-cane juice, would be as follows:

Solids.....	per cent..	15. 00
Sucrose.....	do.....	12. 00
Glucose.....	do.....	1. 50
Purity.....		80. 00

It would be of interest to compare these numbers with the averages of the sorghum worked in the four sugar houses at Attica, Medicine Lodge, Conway Springs, and Meade during the season of 1889, and also to compare it with the general average of the Colman cane during the present season :

	Louisiana sugar cane.	Factory sorghum.	Colman cane.
Total solids.....per cent..	15. 00	17. 46	19. 48
Sucrose.....do ..	12. 00	11. 08	14. 88
Glucose.....do ..	1. 50	2. 37	. 84
Solids not sugar.....do ..	1. 50	4. 01	3. 76
Purity.....do ..	80. 00	63. 45	76. 37

It is easy to see from the above figures why the sugar cane yields a much larger percentage of sugar than sorghum. At the same time a glance will show that the removal of 3.76 per cent of the solids not sugar in the Colman cane would at once place it in the first rank of sugar-producing plants as compared with the others given above.

In the selections made at Sterling particular attention has always been given to the persistence of the sugar content. A variety which retains for a long time a high percentage of sugar in the field is of course preferable to one which rapidly loses its sugar content after having become fully ripe. The former allows more latitude for harvesting the crop, and also permits those canes which from various causes mature later than others time to attain their maximum content before they are harvested, so that when they are finally worked they are in good condition. There are considerable differences in this respect among the different varieties. Some, as for instance the White African, and even the Early Amber, began to retrograde soon after maturity ; others are much more constant. Of all the varieties tried No. 161 has proved the most durable. One plot of this variety has held up its sugar content for 70 days, the longest period ever known, and in spite of exceptionally adverse climatic conditions. Colman cane, which ripens somewhat later, is second in this respect. It seems probable that both these varieties will continue to disclose this good quality and will keep their sugar until second growth is far advanced. With this latter point is closely connected another, viz., the preservation of sugar content in the canes after they have been harvested. It is probable that the two are correlated and that the kind which keeps better in the field than others will also hold up its sugar content better after harvesting. It is very difficult for factories to arrange cutting, hauling, and manufacture to insure the selection of all the canes suitable after harvesting. The losses, therefore, in this respect are very great at every factory and the glucose ratio differs widely between field and diffusion battery.

If varieties of cane could be produced which might be cut and left for a week or so before working, without serious damage, it would be a

great step forward in the sorghum-sugar industry. Work in selection on this line was planned, but owing to the press of other work and early frost it was abandoned during the present season.

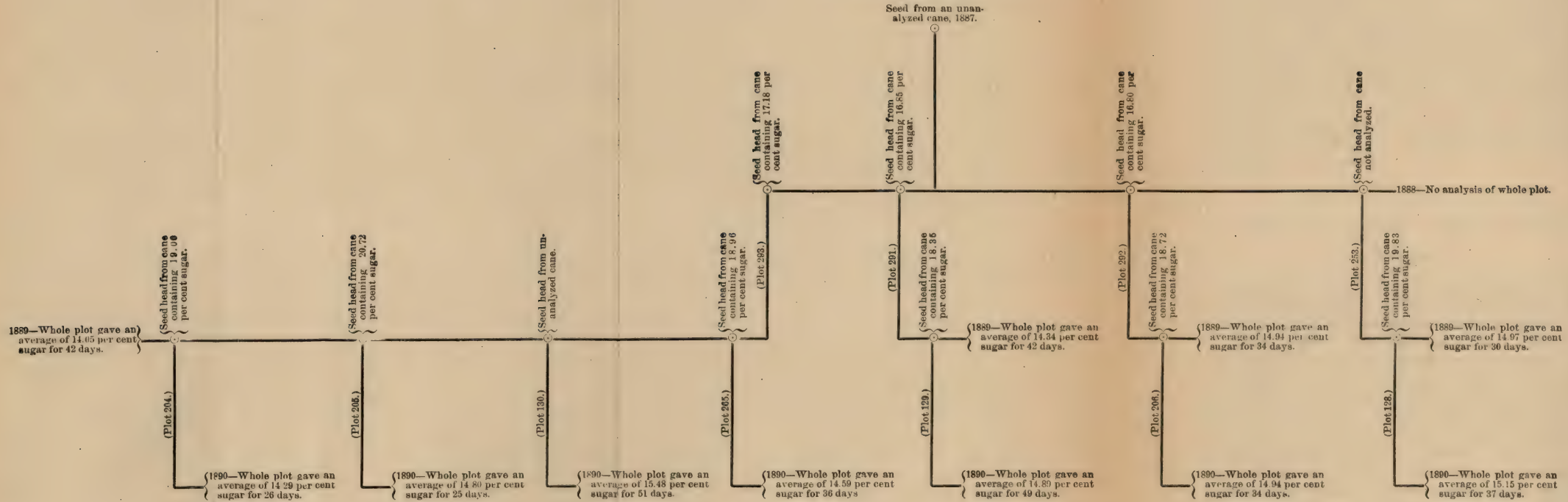
In general it appears that all the varieties of sorghum which have been tested may be divided into several classes: First, those varieties which have only a fair percentage of sugar and low glucose, as, for instance, Sorghum Bicolor, which for 3 years has had an average in its working period of 12.50 per cent of sugar and less than 1 per cent of glucose; second, varieties which have a good percentage of sugar and comparatively high glucose, with a low percentage of solids not sugar; this variety is illustrated by the Early Orange, which for 3 years has shown during its working period about 14 per cent of sugar and 2 per cent. of glucose; third, varieties which have high sugar content and low glucose. This variety is illustrated by Undendebule No. 1, which has shown for 3 years during its working period 15.50 per cent of sucrose and 0.70 of glucose. No. 161 has also shown good results in this direction, having for 2 years an average of 15 per cent sugar and about 0.50 per cent glucose. Fourth, varieties with a moderate percentage of both glucose and sucrose; this class is illustrated by No. 250, an African variety, which has given for 2 years an average of 12.50 per cent sucrose and 1.25 per cent glucose.

STUDIES OF THE DIFFERENT VARIETIES OF SORGHUM.

COLMAN CANE.

The history of this variety is interesting as showing the development of fixed varieties from crosses. A seed head cut in 1887 from a cane resulting from a cross of Kansas Orange and Early Amber was planted in 1888 in a plot by itself. The crop was rather uneven, showing reversions to both parental forms in greater or less degree. From this plot were selected three seed heads by analysis of the canes, and a fourth from physical characteristics. These were last year planted in separate plots and resulted in the production of four "strains" from the original cross. These plots were fairly uniform within themselves, though varying somewhat from one another. All, however, showed good traits, and from one, descended from the second best seed selection made in 1888, was obtained a cane showing 20.72 per cent of sugar in the juice, the highest sorghum analysis ever recorded. This year seven plots were planted with selected seed heads. They were all remarkably uniform within themselves, more so, probably, than those of any other variety, though each varied still from the others, this difference being of course most marked in descendants of different strains. A diagram arranged in the form of a genealogical table has been made to show the lines of descent and render clearer the system of breeding.

PEDIGREE OF COLMAN CANE.



1889—Whole plot gave an
average of 14.05 per cent
sugar for 42 days.

(Seed head from cane
containing 19.00
per cent sugar.

(Plot 204.)

(Whole plot gave an
average of 14.80 per cent
for 25 days.

(Seed head from un-
analyzed cane.

(Plot 130.)

(1890—
average
sugar

Face

GENEALOGICAL TABLE.

The variety whose pedigree is given in the genealogical table was named in honor of ex-Secretary Colman, under whose administration the culture station was established. It was known formerly as "Cross of Amber and Orange."

The canes are short and stocky, somewhat after the Orange type. The seed head is small, but the seeds are rather large. This is a valuable quality, for sprouts from large seeds get a better start than those from small. In period of maturity the variety is medium late, coming in just after Folger's Early. It has a high per cent of sugar, a low per cent of glucose, and is very uniform in analysis. The nonsugars are rather high. In other localities this cane has done very well. At Calumet, in Louisiana, Mr. W. J. Thompson reports it as being good, and at the State Experiment Station, at Manhattan, Kansas, it has given good results. At Attica, Kansas, this year it was regarded as the richest cane grown.

EXPLANATION OF TABLES.

The following tables contain the averages of the analyses of the different varieties of pedigreed sorghum canes at Sterling.

The first column of the tables, headed "parent plot," refers to the original number of the plot, cultivated in 1888 or 1889, from which the parent seed head was obtained.

The column marked "plot" refers to the number of the plot of the season of 1890. These numbers are preserved in order that the pedigree of any given plot may be traced in the record books of the Department.

The "dates" refer to the times within which the analyses were made.

The column marked "days" gives the length of the season during which the examinations were continued and shows approximately the number of days in which the plot would have been fit for sugar-making purposes.

Under the column "No. of analyses" the total number of separate analyses is found from which the average data following are obtained.

The column entitled "other solids" includes all the bodies present in the juice with the exception of the sucrose or cane sugar and the glucose or reducing sugar. It, therefore, includes all the mineral matters which are usually estimated as ash, and carbohydrates, nonsugars such as starch, etc., and the gums and mucilages. In the columns marked "coefficient" are found the results of dividing the percentage of each constituent in the juice by the percentage of total solids therein.

The column headed "sucrose coefficient" represents the same number as is indicated usually by the term "coefficient." The percentage of sucrose present in the juices which can be obtained as crystallizable sugar will increase as the number under the head of "sucrose coefficient" increases and the numbers under the other two heads decrease.

Average of analyses of Colman cane.

1889.

Parent plot, 1888-'89.	Plot, 1890.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
					<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>			
	253	Sept. 16 Oct. 24	38	7	18.73	14.97	1.00	2.76	79.92	5.34	14.74
	291	Sept. 18 Oct. 24	41	6	18.51	14.34	1.23	2.94	77.47	6.65	15.88
	292	Sept. 13 Oct. 24	41	3	19.67	14.94	1.07	3.66	75.96	5.44	18.60
	293	Sept. 13 Oct. 24	41	6	18.27	14.05	1.30	2.92	76.90	7.12	15.98
Means	.....	.....	.....	.....	18.80	14.58	1.15	3.07	77.55	6.12	16.33

1890.

253....	128	Sept. 19 Oct. 15	36	7	19.84	15.15	.77	3.02	76.35	3.90	19.75
291....	129	Aug. 27 Oct. 15	49	9	19.64	14.89	.70	4.05	75.81	3.57	20.62
.....	130	Aug. 25 Oct. 15	51	9	19.79	15.48	.51	3.80	78.22	2.58	19.20
293....	204	Sept. 9 Oct. 4	25	5	19.15	14.29	1.17	3.69	74.62	6.11	19.27
293....	205	Sept. 18 Oct. 7	19	4	19.73	14.80	.99	3.94	75.01	5.01	19.98
292....	206	Sept. 27 Oct. 7	41	6	19.12	15.00	.75	3.37	78.45	3.92	17.13
293....	265	Sept. 2 Oct. 7	36	5	19.06	14.59	1.02	3.45	76.55	5.35	18.10
Means	.....	.....	.....	.....	19.48	14.88	.84	3.76	76.38	4.31	19.31

NO. 160 AND NO. 161.

This new variety originated in 1888 from two selections of crossed canes of Early Amber and Link's Hybrid. The canes of both strains resemble Link's Hybrid, being tall and slender and like it exposed to the danger of being blown over. The seed top of 160 resembles that of Amber, that of 161 is Link's Hybrid in type and smaller than that of any other variety except Undendebule No. 1. No. 160 and No. 161 are practically the same in quality, both having high sugar and low glucose and both being very constant in sugar content. Both ripen early and, as before mentioned, it seems quite possible that by means of continuous selection of early ripening canes the variety can be hastened enough in period of maturity to take the place of Amber.

Averages of analyses of varieties 160 and 161.

VARIETY 160—1889.

Parent plot, 1889.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	160	Sept. 13 Oct. 22	39	8	<i>Pr. cent.</i> 17.86	<i>Pr. cent.</i> 13.84	<i>Pr. cent.</i> .61	<i>Pr. cent.</i> 3.41	77.49	3.42	19.09

VARIETY 160—1890.

160	28	Aug. 25 Oct. 22	58	10	20.06	15.00	.58	4.48	74.77	2.89	22.34
	29	Aug. 25 Oct. 22	58	10	18.93	14.30	.84	3.79	75.54	4.44	20.02
	269	Sept. 2 Oct. 15	43	6	17.76	12.73	.43	4.60	71.67	2.42	25.91
Mean	.....	.....	.....	26	18.92	14.01	.62	4.29	74.05	3.27	22.68

VARIETY 161—1889.

	161	Sept. 4 Oct. 26	43	18	17.12	13.24	.45	3.43	77.33	2.67	20.03
--	-----	--------------------	----	----	-------	-------	-----	------	-------	------	-------

VARIETY 161—1890.

161	36	Aug. 12 Oct. 21	70	12	19.27	14.81	.69	3.77	76.86	3.58	19.56
	37	Aug. 23 Oct. 21	59	11	19.04	14.56	.94	3.54	76.47	4.94	18.59
	271	Sept. 2 Oct. 8	36	7	17.67	12.98	.48	4.21	73.48	2.75	23.77
	272	Aug. 25 Oct. 8	44	8	17.96	13.76	.57	3.63	76.62	3.17	20.21
Mean	.....	.....	.....	38	18.48	14.03	.67	3.78	75.92	3.62	20.46

FOLGER'S EARLY.

This new variety originated in selections made from Early Amber in Iowa by Mr. A. S. Folger.

The seeds selected by him were planted here in 1888 and produced fine canes, which, however, were quite variable in sugar content and other respects. A selection of seed from a single cane planted in plot 205, in 1889, gave canes more uniform in type, and with a much improved sugar per cent. Two plots were planted with unselected seed for comparison. Selections made from plot 205 and planted this year gave a very uniform progeny with a high per cent of sugar and a relatively high glucose, with the incidental low non-sugar. A comparison of the analyses of Folger's Early for the 3 years shows a clearly marked

progressive improvement in quality, and is illustrative of the possibilities of seed selection.

Averages of analyses of Folger's Early.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	248 {	Sept. 10 Oct. 15	} 35	10	<i>Pr.cent.</i> 15.62	<i>Pr.cent.</i> 10.66	<i>Pr.cent.</i> 1.88	<i>Pr.cent.</i> 3.08	68.24	12.04	19.72

1889.

(*)	248 {	Sept. 5 Oct. 1	} 26	7	18.39	14.08	2.03	2.28	76.56	11.04	12.40
	247 {	Sept. 2 Sept. 30	} 28	7	15.18	10.84	1.58	2.76	71.41	10.41	18.18
	248 {	Sept. 16 Oct. 25	} 89	9	15.16	10.84	1.61	2.71	71.50	10.63	17.87

1890.

205 {	110 {	Aug. 25 Oct. 15	} 51	11	18.57	14.28	4.19	3.10	76.89	6.42	16.69
	111 {	Aug. 25 Oct. 15	} 51	11	19.49	14.59	2.03	2.87	74.87	10.43	14.70
	112 {	Aug. 27 Oct. 15	} 49	10	18.48	13.49	2.05	2.94	72.99	11.10	15.91
Mean		-----	-----	32	18.85	14.12	1.76	2.97	74.69	9.31	16.00

* Unselected.

UNDENDEBULE.

This variety came originally from Africa. It was grown by the Department in Washington in 1882 and gave then, as an average of 15 analyses, 13.50 per cent of sugar and less than 1 per cent of glucose. It has been grown here for 3 years and has displayed the same characteristics of high sugar and low glucose, which have been further accentuated by seed selection. In the seeds of this variety sent this station in 1888 by Dr. Collier, director of the New York State Experiment Station, were mixed the seeds of two distinct varieties, which were, however, grown together both that year and last. This year they have been separated and distinguished as Undendebule Nos. 1 and 2. No. 1 is short and stocky, with smaller seed heads than any other variety grown here. The present year it has been much better than No. 2. No. 2 is larger and shorter and has a much heavier seed top than No. 1. Both are medium late, coming in at about the same time as Early Orange. Judged solely by the sucrose and glucose per cents, No. 1 is one of the best of the varieties.

Averages of analyses of Undendebule.

NOS. 1 AND 2—1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	39 }	Sept. 18 Oct. 15 }	27	4	<i>Pr.cent.</i> 17.17	<i>Pr.cent.</i> 12.31	<i>Pr.cent.</i> .73	4.13	71.69	4.25	24.06

NOS. 1 AND 2—1889.

39	31 }	Oct. 1 Oct. 10 }	9	2	21.15	16.28	.57	4.30	76.79	2.69	20.52
39	254 }	Sept. 12 Oct. 25 }	43	10	17.95	13.69	.82	3.44	76.06	4.55	19.39
39	397 }	Oct. 4 Oct. 25 }	21	5	18.95	14.78	.68	3.49	78.00	3.59	18.41

NO. 1—1890.

254	114 }	Sept. 12 Oct. 15 }	33	6	21.10	15.72	.63	4.75	74.50	2.98	22.52
	116 }	Sept. 13 Oct. 18 }	35	5	21.81	16.42	.46	4.93	75.29	2.11	22.60
	117 }	Sept. 12 Oct. 15 }	33	6	21.07	15.72	.68	4.67	74.61	3.23	22.16
Average					21.33	15.95	.59	4.79	74.77	2.77	22.46

NO 2.—1890.

31	113 }	Sept. 2 Oct. 15 }	43	7	18.95	13.51	1.33	4.11	71.29	7.02	21.69
254	115 }	Sept. 12 Oct. 4 }	22	4	18.84	13.78	.88	4.18	73.14	4.67	22.19
Average					18.89	13.64	1.10	4.15	71.78	6.16	22.06

*Unselected.

LINK'S HYBRID.

This variety has always been considered one of the best for sugar making since the first distribution of its seeds by Commissioner Le Duc. It is very late in maturing, the last analyses taken before frost being generally the best. It thus affords but little time to work the canes when at their best, and the occasional complaints heard of the sugar-yielding qualities of the variety are mainly attributable to too early harvesting. The stalks are tall and slender, and, having a heavy seed head; are liable to be broken down by the wind. In the 3 years' work here more cane has been lost from Link's Hybrid in this way than from any other, perhaps than from all other varieties. Attempts have been made to remedy this defect by crossing the variety with others which are shorter and better rooted, such as the Oranges, and with very fair suc-

cess. It has also been done by simply selecting seed from canes of the pure variety possessing the desired quality, of which plot 65 is an example. More work has been done here upon Link's Hybrid than upon any other variety. This year 57 plots were planted with selections from it. Some of these plots arrived at maturity a month before those from unselected seed, the canes having all the desirable qualities of Link's Hybrid and a much longer working period. The quality of the juice is very good, though averaging better last year than this, as the frost caught it in the midst of the sugar-forming period. The sugar per cent is generally high and the glucose low. Last year the non-sugar was lower than in any other variety with correspondingly low glucose, but this year in consequence possibly of the frost it is much higher, and follows the general rule.

The Link's Hybrid, improved as it may be, should be a good variety for sugar making in this latitude.

Averages of analyses of Link's Hybrids.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non sugars coefficient.
	0	Sept. 21 Oct. 24	33	25	<i>Pr.cent.</i> 18.06	<i>Pr.cent.</i> 13.02	<i>Pr.cent.</i> 1.06	<i>Pr.cent.</i> 3.98	72.09	5.87	22.04

1889.

0	116	Sept. 17 Oct. 22	35	7	18.46	15.18	.65	2.63	82.23	3.53	14.24
	149	Sept. 30 Oct. 22	22	4	18.38	14.77	.57	3.04	80.35	3.11	16.54
	150	Sept. 20 Oct. 22	32	6	18.30	14.75	.55	3.00	80.60	3.01	16.39
	153	Oct. 2 Oct. 22	20	6	19.94	15.49	.55	3.90	77.68	2.76	19.56
	154	Sept. 25 Oct. 22	27	5	19.08	15.17	.57	3.34	79.51	3.00	17.51
	162	Sept. 17 Oct. 22	35	8	18.93	14.91	.66	3.36	78.76	3.48	17.75
	163	Sept. 25 Oct. 22	27	5	19.29	15.21	.72	3.36	78.85	3.78	17.36
	164	Sept. 25 Oct. 22	27	6	19.83	15.56	.83	3.44	78.47	4.18	17.35
	165	Sept. 20 Oct. 22	32	5	19.53	15.09	.88	3.56	77.26	4.51	18.23
	166	Sept. 25 Oct. 22	27	5	19.96	15.36	.76	3.84	76.95	3.81	19.23
	244	Oct. 3 Oct. 25	22	5	19.39	15.32	.64	3.43	79.01	3.30	17.69
	Mean	-----	-----	-----	19.19	15.16	.65	3.38	79.00	3.39	17.61

Averages of analyses of Link's Hybrids—Continued.

1890.

Parent plot, 1888-89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugar.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
					<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>			
(*)	30	Sept. 1 Oct. 22	51	9	18.23	13.24	1.05	3.94	72.63	5.75	21.62
164	31	Sept. 1 Oct. 22	51	9	18.88	13.91	.98	3.99	73.67	5.16	21.17
	33	Sept. 18 Sept. 29	11	2	19.71	13.50	1.56	4.65	68.49	7.92	23.59
163	35	Sept. 8 Oct. 21	43	9	19.21	13.78	1.17	4.26	71.74	6.08	22.17
	38	Sept. 8 Sept. 25	17	4	18.21	13.61	1.57	3.03	74.74	8.62	16.64
	42	Sept. 8 Oct. 10	32	7	17.81	12.63	1.27	3.91	70.91	7.13	21.96
153	43	Sept. 8 Sept. 18	40	4	18.64	13.75	.70	4.19	73.76	3.76	22.48
	44	Sept. 8 Oct. 10	32	5	17.55	12.47	1.16	3.92	71.06	6.61	22.33
150	47	Sept. 8 Sept. 30	22	6	17.73	12.61	1.44	3.68	71.14	8.11	20.75
	48	Sept. 8 Sept. 30	22	6	17.36	11.70	1.46	4.20	67.39	8.41	24.20
	49	Aug. 26 Sept. 30	35	6	18.30	12.96	1.43	3.91	70.82	7.81	21.37
162	50	Aug. 26 Oct. 10	45	7	17.18	12.30	1.02	3.86	71.59	5.94	22.47
150	53	Sept. 8 Oct. 21	43	6	18.50	13.33	1.01	4.16	72.08	5.42	22.50
153	54	Sept. 1 Oct. 21	50	9	18.62	13.48	.83	4.31	72.40	4.46	23.14
166	55	Sept. 8 Oct. 13	35	7	19.27	13.49	1.07	4.71	70.00	5.55	24.45
	56	Sept. 1 Oct. 21	50	10	18.91	13.96	1.11	3.84	73.82	5.87	20.31
	57	Sept. 1 Oct. 13	42	8	19.49	14.22	.89	4.38	72.96	4.57	22.47
165	58	Sept. 1 Oct. 21	50	8	19.88	14.20	1.34	4.34	71.43	6.74	21.83
116	61	Sept. 8 Oct. 13	42	8	18.75	13.49	1.20	4.06	71.95	6.40	21.65
	65	Sept. 2 Oct. 22	50	9	19.26	13.90	1.09	4.27	72.18	5.65	22.17
	66	Sept. 2 Oct. 22	50	8	19.82	14.34	.84	4.64	72.35	4.24	23.41
Mean.	.....	.....	.....	.....	18.63	13.37	1.15	4.11	71.77	6.17	22.06

* Unselected.

WHITE INDIA

Is also called White Mammoth and Enyama. White India canes are large, erect, and strongly rooted and it transmits these characteristics to its crosses. Were it somewhat earlier in maturing this would be a fair variety. The seeds are white. The sugar content of the juice is only moderate, and the glucose and nonsugar per cents are both high.

Averages of analyses of White India.

1888.

Parent plot, 1888-'89	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
					<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>			
	68 {	Sept. 12 {	27	4	17.50	11.43	2.31	3.76	65.32	13.20	21.48
	69 {	Oct. 9 {	20	4	16.44	11.29	1.27	3.88	68.67	7.73	23.60
	70 {	Sept. 19 {	20	4	17.41	11.92	1.67	3.82	68.47	9.59	21.94
Mean.	-----	-----	-----	-----	17.12	11.55	1.75	3.82	67.49	10.19	22.32

1889.

	28 {	Oct. 8 {	17	4	14.76	8.69	1.48	4.59	58.83	10.06	31.11
	401 {	Oct. 25 {	2	2	14.60	9.57	2.19	2.84	65.55	15.00	19.45
Mean.	-----	-----	-----	-----	14.68	9.13	1.82	3.72	62.19	12.53	25.28

1890.

	237	Sep. 12	1	1	17.14	12.20	1.50	3.44	71.18	8.75	20.07
--	-----	---------	---	---	-------	-------	------	------	-------	------	-------

HONDURAS.

This variety was grown here in all three years, but was cut off by the frost this season. Honduras is a very late variety, too late for sugar-making in this latitude as it requires 5.5 months to mature. Considerable improvement in this regard has been effected by seed selection. The canes are very large and the variety gives a much higher tonnage than any other. The per cent of sugar in the juice is low and the glucose relatively high, but the purity is often very good. This is probably the only juice low in solids in which the purity ever gets over 75.

Averages of analyses of Honduras.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	37 {	Oct. 6 {	9	2	15.64	9.44	3.24	2.96	60.35	18.94	20.71

Averages of analyses of Honduras—Continued.

1889.

Parent plot. 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	3 {	Oct. 8 Oct. 25	17	3	16.22	12.69	1.19	2.34	78.24	7.34	14.42
	103 {	Oct. 8 Oct. 25	17	4	16.25	12.75	1.36	2.14	78.46	8.37	13.17
	105 {	Oct. 8 Oct. 26	18	3	16.80	11.88	1.85	3.07	70.71	11.02	18.27
	106 {	Oct. 8 Oct. 25	17	4	15.87	10.88	1.89	3.10	68.56	11.91	19.53
	115 {	Sept. 20 Oct. 12	22	4	14.42	8.82	3.07	2.53	61.15	21.29	17.56
	119 {	Sept. 14 Oct. 8	24	7	16.42	11.97	1.44	3.01	72.90	8.77	18.33
	120 {	Sept. 14 Oct. 8	24	6	16.45	11.71	2.67	2.07	71.19	16.23	12.58
	236 {	Oct. 4 Oct. 25	18	3	15.77	12.00	1.88	1.89	76.10	11.92	11.98
Mean					16.03	11.59	1.92	2.52	72.30	11.98	15.72

* Unselected.

UBEHLANA.

This variety gives fine canes, but is somewhat late in ripening. Two subvarieties exist, distinguished only by color of seed.

Averages of analyses of Ubehlana.

1888.

Parent plot. 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	61 {	Oct. 6 Oct. 15	9	2	<i>Pr. cent.</i> 18.85	<i>Pr. cent.</i> 13.10	<i>Pr. cent.</i> 2.33	<i>Pr. cent.</i> 3.42	60.50	12.36	18.14

1889.

C1 {	34 {	Oct. 8 Oct. 25	17	3	18.46	13.36	1.84	3.26	72.35	10.00	17.65
	226 {	Oct. 3 Oct. 25	22	3	16.93	11.52	2.87	2.54	68.05	16.95	15.00
	326 {	Oct. 5 Oct. 10	5	2	15.44	11.31	1.61	2.52	73.25	10.43	16.32
	378 {	Oct. 10 Oct. 26	16	2	18.10	11.91	2.69	3.50	65.80	14.96	19.34
Mean					17.24	12.03	2.25	2.96	69.78	13.05	17.17

1890.

(*) {	188 {	Sept. 12 Oct. 7	25	4	18.65	11.57	2.89	4.19	62.04	15.50	22.46
	192 {	Sept. 13 Sept. 27	14	3	18.72	13.45	2.16	3.11	71.84	11.54	16.62
Mean					18.68	12.51	2.52	3.65	66.94	13.02	19.54

*Unselected.

WHITE AFRICAN.

White African, though a favorite variety in New Jersey and Delaware, has proved an inferior one here in its three years' trial. It spoils soon after becoming ripe.

Averages of analyses of White African.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of anal- yses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coeffi- cient.	Glucose coeffi- cient.	Non- sugars coeffi- cient.
(*)	77 {	Sept. 11 Sept. 19	} 8	2	<i>Pr.cent.</i> 12.97	<i>Pr.cent.</i> 5.73	<i>Pr.cent.</i> 2.04	<i>Pr.cent.</i> 5.20	44.18	15.73	40.09

* Unselected.

1889.

77	237 {	Sept. 6 Sept. 26	}	20	7	17.21	12.21	1.41	3.59	70.95	8.20	20.85
----	-------	---------------------	---	----	---	-------	-------	------	------	-------	------	-------

1890.

237	186 {	Sept. 2 Sept. 12	}	10	2	19.02	13.32	1.94	3.76	70.03	10.20	19.97
-----	-------	---------------------	---	----	---	-------	-------	------	------	-------	-------	-------

WHITING'S EARLY.

This variety ripens earlier than Amber, but it has little else to recommend it. The canes are very small and are variable in quality. The sugar content is low and the glucose high.

Average of analyses of Whiting's Early.

1888.

Parent plot, 1888-89.	Plot.	Dates.	Length of season in days.	No. of anal- yses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coeff- icient.	Glucose coeff- icient.	Non- sugars coeff- icient.
(*)	233 {	Aug. 25 Sept. 6	} 12	3	<i>Pr.cent.</i> 16.00	<i>Pr.cent.</i> 10.13	<i>Pr.cent.</i> 2.12	<i>Pr.cent.</i> 3.75	63.31	13.25	23.44

* Unselected.

1889.

233	399 {	Aug. 30 Sept. 21	}	22	7	15.41	10.26	1.77	3.38	66.58	11.48	21.94
-----	-------	---------------------	---	----	---	-------	-------	------	------	-------	-------	-------

1890.

399	176 {	July 20 Aug. 21	}	32	6	13.41	7.87	1.75	3.79	58.70	13.04	28.26
-----	-------	--------------------	---	----	---	-------	------	------	------	-------	-------	-------

BLACK AFRICAN.

Black African canes are tall and slender, and have a good sugar and medium glucose content. They ripen at about the same time as those of Orange. The variety is highly prized at the sugar factories in Topeka and Medicine Lodge.

Averages of analyses of Black African.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	109 {	Sept. 11 Oct. 25	} 44	11	<i>Pr.cent.</i> 18.66	<i>Pr.cent.</i> 14.24	<i>Pr.cent.</i> .81	<i>Pr.cent.</i> 3.61	76.32	4.34	19.34

* Unselected.

1890.

109 {	104 {	Aug. 25 Oct. 15	} 51	11	19.13	13.05	1.31	4.77	68.2 ₃	6.84	24.94
	105 {	Sept. 15 Oct. 25	} 42	6	18.65	13.66	1.34	3.65	73.24	7.19	19.57
	Mean	.....	.....	.....	18.89	13.56	1.32	4.21	70.73	7.02	22.25

WHITE ENFIELD.

The seed of the White Enfield was obtained from Texas. The canes are large and handsome, and late in maturing. They have a large seed top and white seed. Sugar, glucose, and purity are low.

Averages of analyses of White Enfield.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	230 {	Oct. 7 Oct. 25	} 18	4	<i>Pr.cent.</i> 16.58	<i>Pr.cent.</i> 11.80	<i>Pr.cent.</i> .82	<i>Pr.cent.</i> 3.96	71.17	4.94	23.89

1890.

230	236 {	Sept. 6 Sept. 23	} 17	2	14.60	9.40	1.16	4.04	64.38	7.95	27.67
----------	-------	---------------------	------	---	-------	------	------	------	-------	------	-------

*Unselected.

CHINESE.

Chinese was one of the first varieties of sorghum to be introduced into this country. The sugar content is only fair, the glucose and non-sugar are high.

Averages of analyses of Chinese.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of anal- yses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity of sucrose coeffi- cient.	Glucose coeffi- cient.	Non- sugars coeffi- cient.
(*)	68	Sept. 7	38	6	<i>Pr.cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr.cent.</i>			
		Oct. 15			16.31	9.97	2.17	4.17	61.13	13.31	25.56
	215	Sept. 17	21	3	15.82	9.34	2.17	4.31	59.04	13.72	27.24
		Oct. 8									
	216	Sept. 18	27	4	15.85	9.31	2.71	3.83	58.74	17.16	24.10
		Oct. 15									
	232	Sept. 17	28	5	17.05	10.98	1.99	4.08	64.40	11.67	23.93
		Oct. 15									
Mean	.....	.....	.....	.....	16.26	9.90	2.26	4.10	60.88	13.90	25.22

1889.

	9	Oct. 1	7	3	18.54	12.53	1.37	4.64	67.58	7.38	25.04
		Oct. 8									
	39	Oct. 1	24	5	17.53	13.05	1.16	3.32	74.44	6.62	18.94
		Oct. 25									
	58	Sept. 14	24	5	16.02	11.61	1.68	2.73	72.47	10.49	17.04
		Oct. 8									
	76	Sept. 21	17	2	15.41	11.08	1.20	3.13	71.90	7.79	20.31
		Oct. 8									
	79	Sept. 1	11	4	16.44	12.39	1.62	2.43	75.37	9.85	14.78
		Oct. 2									
	81	Sept. 14	28	4	16.79	12.19	1.72	2.88	72.61	10.24	17.15
		Oct. 12									
	199	Sept. 5	26	5	16.58	11.08	2.52	2.98	66.82	15.20	17.98
		Oct. 1									
	223	Sept. 14	41	5	15.63	10.60	2.43	2.60	67.82	15.55	16.63
		Oct. 25									
	229	Sept. 2	35	7	15.69	10.23	2.02	3.44	65.22	12.86	21.92
		Oct. 7									
	260	Sept. 19	14	5	16.05	11.39	2.32	2.34	70.97	14.45	14.58
		Oct. 3									
Mean	.....	.....	.....	.....	16.47	11.61	1.82	3.04	70.50	11.05	18.45

1890.

(*)	15	Sept. 6	6	3	18.25	12.57	1.68	4.00	68.88	9.20	21.92
		Sept. 12									

* Unselected.

SORGHUM BICOLOR.

This kind is sometimes called "Red Sorghum." The canes are rather small and each has three seed heads. In the 3 years of trial here the variety has uniformly given very low glucose, moderate sugar, and fair purity.

Averages of analyses of Sorghum Bicolor.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
					<i>Pr.cent.</i>	<i>Pr.cent.</i>	<i>Pr.cent.</i>	<i>Pr.cent.</i>			
	15	Sept. 18	8	2	18.00	12.13	.76	5.11	67.39	4.22	28.39
	52	Sept. 26									
		Sept. 18	32	6	16.90	11.10	.79	5.01	65.68	4.67	29.65
		Oct. 20									
Mean.	.....	.....	.....	.....	17.45	11.61	.77	5.07	66.54	4.44	29.02

1889.

	51	Oct. 4	21	4	17.87	12.89	.60	4.38	72.12	3.36	24.52
		Oct. 25									
	70	Oct. 4	21	4	18.51	13.50	.57	4.44	72.92	3.08	24.00
		Oct. 25									
	74	Oct. 1	7	2	17.32	13.27	.89	3.16	76.62	5.14	18.24
		Oct. 8									
	231	Sept. 9	32	7	16.94	12.07	.85	4.02	71.25	5.02	23.73
		Oct. 11									
	258	Sept. 9	32	8	16.90	11.62	1.09	4.19	68.76	6.45	24.79
		Oct. 11									
	259	Sept. 9	45	9	17.22	12.11	1.07	4.04	70.32	6.22	23.46
		Oct. 24									
	261	Sept. 16	17	3	16.47	11.57	1.26	3.64	70.25	7.65	22.10
		Oct. 3									
Mean.	.....	.....	.....	.....	17.31	12.43	.90	3.98	71.80	5.20	23.00

1890.

259	118	Sept. 9	36	5	18.88	13.30	.76	4.82	70.44	4.03	25.53
		Oct. 15									
70	119	Sept. 2	43	7	18.27	12.61	.86	4.80	69.00	4.75	26.25
		Oct. 15									
	120	Sept. 9	36	6	18.90	13.30	.79	4.81	70.37	4.18	25.45
		Oct. 15									
261	121	Sept. 13	32	5	18.37	12.40	.73	5.24	67.50	3.98	28.52
		Oct. 15									
	122	Sept. 9	29	5	18.23	12.85	1.37	4.01	70.49	7.51	22.00
		Oct. 8									
51	123	Sept. 9	29	5	18.00	12.31	1.29	4.40	68.39	7.17	24.44
		Oct. 8									
Mean.	.....	.....	.....	.....	18.44	12.80	.96	4.68	69.41	5.21	25.38

PRICE'S NEW HYBRID.

This variety is not very early, has low sugar and purity and high glucose.

Averages of analyses of Price's New Hybrid.

1888.

Parent plot. 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	101 {	Sept. 3 Sept. 6	{ 3	2	<i>Pr.cent.</i> 16.47	<i>Pr.cent.</i> 9.98	<i>Pr.cent.</i> 2.83	<i>Pr.cent.</i> 3.66	60.60	17.18	22.22

1889.

101 ...	251 {	Sept. 9 Sept. 23	{ 14	5	14.88	9.47	2.31	3.10	63.64	15.51	20.83
---------	-------	---------------------	------	---	-------	------	------	------	-------	-------	-------

* Unselected.

JYANGENTOMBI.

Chinese type of canes. Sugar content good, glucose and purity fair in 1889. This year's stand was nearly destroyed by blowing sand.

Averages of analyses of Jyangentombi.

1889.

Parent plot. 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	35 {	Oct. 1 Oct. 25	{ 24	5	<i>Pr.cent.</i> 19.00	<i>Pr.cent.</i> 14.31	<i>Pr.cent.</i> 1.02	<i>Pr.cent.</i> 3.67	75.32	5.36	19.32

1890.

35	189 {	Sept. 13 Sept. 16	{ 3	2	18.05	11.82	2.09	4.14	65.48	11.53	22.94
----------	-------	----------------------	-----	---	-------	-------	------	------	-------	-------	-------

* Unselected.

SORGHUM BLEU.

Tall and erect canes. The variety is not desirable.

Averages of analyses of Sorghum Bleu

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	101 {	Oct. 4 Oct. 25	} 21	3	<i>Pr. cent.</i> 17.48	<i>Pr. cent.</i> 12.52	<i>Pr. cent.</i> 1.14	<i>Pr. cent.</i> 3.82	71.62	6.52	21.86

HONEY DRIP.

Honey drip canes are short, stocky, and strongly rooted. Their quality is poor.

Averages of analyses of Honey Drip.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	100 {	Aug. 31 Sept. 13	} 13	7	<i>Pr. cent.</i> 14.25	<i>Pr. cent.</i> 7.04	<i>Pr. cent.</i> 3.12	<i>Pr. cent.</i> 40.9	49.40	21.90	28.70

UFATANE.

This is a South African variety. The canes are of medium size and bear a heavy seed top. Sugar content fair.

Averages of analyses of Ufatane.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	18 {	Oct. 4 Oct. 26	} 52	4	<i>Pr. cent.</i> 17.42	<i>Pr. cent.</i> 13.63	<i>Pr. cent.</i> .69	<i>Pr. cent.</i> 3.10	78.24	3.96	17.80

1890.

18.....	190 {	Sept. 12 Oct. 3	} 21	4	16.40	11.03	1.33	4.04	67.26	8.11	24.63
---------	-------	--------------------	------	---	-------	-------	------	------	-------	------	-------

* Unselected.

LARGE GOOSE NECK.

This variety never matured here.

Analysis of Large Goose Neck.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	192	Oct. 7	1	1	<i>Pr.cent.</i> 10.60	<i>Pr.cent.</i> 2.34	<i>Pr.cent.</i> 4.92	<i>Pr.cent.</i> 3.34	22.08	46.41	31.51

*Unselected.

EARLY GOOSE NECK.

The seed of this variety was received from South Carolina, where it is highly recommended. Its goose-neck habit makes handling and topping the cane rather difficult. The quality of the juice is fair.

Averages of analyses of Early Goose Neck.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	75 {	Sept. 11 Oct. 9	} 28	5	<i>Pr.cent.</i> 17.73	<i>Pr.cent.</i> 12.00	<i>Pr.cent.</i> 2.02	<i>Pr.cent.</i> 3.71	67.68	11.40	20.92

*Unselected.

UKUBANE.

Ukubane was tried last year. The sugar per cent was fair, but the variety was not deemed worth further trial.

Average of analyses of Ukubane.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	32 {	Sept. 21 Oct. 11	} 20	4	<i>Pr.cent.</i> 18.58	<i>Pr.cent.</i> 13.65	<i>Pr.cent.</i> 1.43	<i>Pr.cent.</i> 3.50	73.47	7.69	18.84

* Unselected.

EARLY AMBER

Is at present the best early maturing variety. Earlier varieties have been grown here, but as a rule have not amounted to much. The canes of these very early kinds are always small and the juice poor and variable. The Amber for 3 years has given here moderate sugar per cents, rather high glucose, and low nonsugars. It has not a long working period, usually beginning to retrograde soon after maturity.

Averages of analyses of Early Amber.

1888.

Parent plot 1888-'89.	Plot.	Dates.	Length of season in days.	No. of anal- yses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coeffi- cient.	Glucose coeffi- cient.	Non- sugars coeffi- cient.
(*)	92 { 231 { 237 {	Aug. 24 Sept. 1 Aug. 30 Sept. 26 Aug. 31 Sept. 24	8 27 24	3 3 4	Pr.cent. 17.78 13.35 13.85	Pr.cent. 12.73 7.35 8.43	Pr.cent. 1.81 2.58 2.64	Pr.cent. 3.24 3.42 2.78	71.60 55.05 60.87	10.18 19.32 19.06	18.22 25.63 20.07
Mean	-----	-----	-----	-----	15.00	9.50	2.35	3.15	63.34	15.66	21.00

* Unselected.

1889.

	1 {	Sept. 21 {	35	4	15.33	11.50	1.41	2.42	75.02	9.20	15.78		
	49 {	Oct. 26 {			15.93	11.59	1.21	3.13	72.75	7.60	19.65		
		Oct. 25 {											
	50 {	Sept. 21 {			20	4	15.78	11.80	1.28	2.70	74.78	8.11	17.11
	235 {	Oct. 11 {											
		Aug. 30 {	24	12	16.22	11.88	1.10	3.24	73.23	6.77	20.00		
		Sept. 23 {											
Mean.	-----	-----	-----	-----	15.81	11.69	1.25	2.87	73.94	7.91	18.15		

1890.

(A)	{	14	{	Sept. 6	{	9	2	18.57	12.63	2.00	3.94	68.02	10.77	21.21
		25	{	Sept. 15 Aug. 1 Sept. 13				{	43	10	17.60	13.05	1.01	3.54	74.15	5.74	20.11
Mean	-----										18.08	12.84	1.50	3.74	71.02	8.29	20.69

* Unselected.

THE ORANGES (NEEAZANA).

The varieties known as Early Orange, Late Orange, Kansas Orange New Orange, Improved Orange, and Rio Blanco, are much alike physically. All give short, stocky, well-rooted canes, and all have juices distinguished by a good sugar per cent and a high glucose and an extremely low nonsugar content. They all ripen at about the same time, there being little difference between Late and Early Orange in this respect, despite their names. Rio Blanco was brought here from Mexico last year.

Averages of analyses of Early Orange.

1888.

Parent plot. 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	83	Sept. 12	27	4	<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>			
		Oct. 9			16.91	10.64	2.62	3.65	62.92	15.50	21.53
	228	Sept. 7	14	5	16.86	10.85	2.71	3.30	64.35	16.08	19.57
		Sept. 21									
	236	Sept. 17	9	3	15.78	9.71	3.07	3.00	61.53	19.45	19.01
		Sept. 26									
Mean.	.....	.....	.....	.....	16.52	10.40	2.80	3.32	62.93	17.02	20.05

1889.

	207	Sept. 12	27	6	17.38	11.88	3.12	2.38	68.36	17.95	13.69
		Oct. 9									
	239	Sept. 9	32	7	17.14	12.12	2.19	2.83	70.71	12.78	16.51
		Oct. 11									
	242	Sept. 9	32	7	15.46	10.66	2.41	2.39	68.95	15.59	15.46
		Oct. 11									
	382	Oct. 5	9	4	18.63	13.83	2.35	2.45	74.23	12.62	13.15
		Oct. 14									
Mean.	.....	.....	.....	.....	17.15	12.12	2.52	2.51	70.55	14.75	14.70

1890.

239	178	Sept. 2	32	5	18.94	13.65	2.15	3.14	72.08	11.35	16.57
		Oct. 4									

* Unselected.

Averages of analyses of New Orange.

1888.

Parent plot. 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	88	Sept. 5	22	4	<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>	<i>Pr. cent.</i>			
		Sept. 27			15.27	7.77	4.32	3.18	50.88	28.29	20.83

1889.

	12	Sept. 18	37	5	18.59	13.75	1.99	2.85	73.90	10.71	15.39
		Oct. 25									
	193	Sept. 20	22	7	18.72	13.66	2.74	2.32	72.98	14.63	12.39
		Oct. 12									
	216	Sept. 27	10	3	18.65	13.65	2.07	2.93	73.18	11.10	15.72
		Oct. 7									
	238	Sept. 16	39	7	18.65	13.53	2.20	2.92	72.54	11.80	15.66
		Oct. 25									
Mean	.....	.....	.....	.....	18.65	13.65	2.25	2.75	73.19	12.07	14.74

1890.

193	177	Sept. 13	13	3	19.43	14.05	2.66	2.69	72.46	13.69	13.85
		Sept. 26									

* Unselected.

Averages of analyses of Improved Orange.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
					Pr. cent.	Pr. cent.	Pr. cent.	Pr. cent.			
	204 {	Oct. 24 Oct. 26	{ 2	2	17.84	12.96	2.31	2.57	72.65	12.95	14.40
	213 {	Sept. 21 Oct. 1	{ 10	4	18.75	13.95	2.58	2.22	74.40	13.76	11.84
	370 {	Oct. 3 Oct. 10	{ 7	2	20.27	14.05	3.02	3.20	69.32	11.90	15.78
	371 {	Sept. 18 Oct. 10	{ 22	4	16.76	12.12	2.09	2.55	72.31	12.47	15.22
Mean.	-----	-----	-----	-----	18.40	13.27	2.50	2.63	72.12	13.58	14.30

Averages of analyses of Rio Blanco.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
					Pr. cent.	Pr. cent.	Pr. cent.	Pr. cent.			
(*)	107 {	Sept. 11 Oct. 25	{ 44	6	18.16	14.21	1.78	2.17	78.25	9.80	11.95

* Unselected.

1890.

107 .. {	102 {	Sept. 13 Sept. 25	{ 12	4	20.46	15.17	1.79	3.50	74.14	8.74	17.11
	103 {	Sept. 2 Oct. 15	{ 43	8	20.64	14.98	2.44	3.22	72.58	11.82	15.60
	183 {	Sept. 2 Sept. 9	{ 7	4	18.69	13.69	2.79	2.21	73.25	14.93	11.82
Mean	-----	-----	-----	-----	19.93	14.62	2.34	2.97	73.35	11.75	14.90

Averages of analyses of Late Orange.

1888.

Parent plot, 1888.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
					Pr. cent.	Pr. cent.	Pr. cent.	Pr. cent.			
	89 {	Sept. 19 Oct. 9	{ 20	2	17.50	11.65	2.69	3.16	66.56	15.38	18.06

1889.

	241 {	Sept. 27 Oct. 25	{ 28	5	18.61	14.41	1.65	2.55	77.43	8.86	13.71
	386 {	Oct. 5 Oct. 11	{ 6	3	18.86	13.99	2.46	2.41	74.18	13.04	12.78
Mean	-----	-----	-----	-----	18.73	14.20	2.05	2.48	75.81	10.95	13.24

Average analyses of Kansas Orange.

1888.

Parent plot 1888-'89.	Plot.	Dates.	Length of season in days.	No. of anal- yses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coeffi- cient.	Glucose coeffi- cient.	Non- sugars coeffi- cient.
	82 {	Sept. 19 Sept. 27	} 8	2	<i>Pr. cent.</i> 14.99	<i>Pr. cent.</i> 9.38	<i>Pr. cent.</i> 1.95	<i>Pr. cent.</i> 3.66	62.37	13.01	24.42

1889.

	200 {	Sept. 18 Oct. 1	} 13	5	18.17	13.62	1.85	2.70	75.00	10.14	14.88
	240 {	Sept. 9 Oct. 7	} 28	2	15.48	11.26	1.75	2.47	72.74	11.30	15.96
	390 {	Oct. 10 Oct. 26	} 16	2	17.71	13.11	.85	3.75	74.02	4.81	21.17
Mean.	.....	.....	.....	.....	17.11	12.66	1.48	2.97	74.00	8.65	17.35

1890.

200	181 {	Sept. 2 Sept. 27	} 25	4	17.67	11.80	2.65	3.22	66.78	15.00	18.22
-----	-------	---------------------	------	---	-------	-------	------	------	-------	-------	-------

GOLDEN ORANGE.

This variety was first grown here from some seeds taken from stray canes found in a field of Honduras in 1888. It does not resemble the other Orange varieties in its physical properties.

Average of analyses of Golden Orange.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of anal- yses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coeffi- cient.	Glucose coeffi- cient.	Non- sugars coeffi- cient.
	117 {	Sept. 11 Oct. 12	} 31	9	<i>Pr. cent.</i> 17.18	<i>Pr. cent.</i> 13.15	<i>Pr. cent.</i> 1.82	<i>Pr. cent.</i> 2.21	76.54	10.59	12.87
	214 {	Sept. 21 Oct. 22	} 31	6	17.20	11.82	2.27	3.11	68.72	13.20	18.08
Mean.	.....	.....	.....	.....	17.19	12.48	2.04	2.67	72.60	11.86	15.54

1890.

	71 {	Sept. 2 Oct. 22	} 50	9	18.64	13.34	1.59	3.71	71.56	8.54	19.90
	72 {	Sept. 1 Oct. 13	} 42	8	18.69	13.78	1.80	3.11	73.73	9.63	16.64
Mean.	.....	.....	.....	.....	18.66	13.56	1.70	3.40	72.64	9.11	18.25

VARIETY No. 208.

This variety originated from a cross of Link's Hybrid and Early Amber.

Averages of analyses of Variety 208.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	208 {	Sept. 12 Oct. 9 }	27	7	<i>Pr. cent.</i> 19.03	<i>Pr. cent.</i> 14.78	<i>Pr. cent.</i> .95	<i>Pr. cent.</i> 3.30	77.66	5.00	17.34

1890.

208 ...	59 {	Sept. 12 Oct. 21 }	39	8	19.76	15.07	.77	3.92	76.26	3.90	19.84
208 ...	268 {	Sept. 26 Oct. 15 }	19	3	19.27	15.25	1.01	3.61	79.14	5.24	15.62
Mean	.....	.....	.....	.....	19.51	15.16	.89	3.46	77.70	4.57	17.73

VARIETY NO. 244.

This came from a cross of Link's Hybrid and Early Amber.

Averages of analyses of variety 244.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	214 {	Oct. 3 Oct. 25 }	22	5	<i>Pr. cent.</i> 19.39	<i>Pr. cent.</i> 15.32	<i>Pr. cent.</i> .64	<i>Pr. cent.</i> 3.43	79.01	3.30	17.69

1890.

214 ...	63 {	Sept. 2 Oct. 2 }	30	7	18.93	14.41	.76	3.76	76.12	4.02	19.86
---------	------	---------------------	----	---	-------	-------	-----	------	-------	------	-------

DUTCHER'S HYBRIDS, NOS. 1, 2, AND 3.

Averages of analyses of Dutcher's Hybrids.

1890.—No. 1.

Parent plot. 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	193 {	Aug. 22 Sept. 13	} 22	4	<i>Pr. cent.</i> 16.72	<i>Pr. cent.</i> 12.43	<i>Pr. cent.</i> 1.22	<i>Pr. cent.</i> 3.07	74.34	9.30	18.36

No. 2.

(*)	194 {	Sept. 2 Sept. 13	} 11	3	17.22	13.08	1.46	2.68	75.96	8.48	15.56
-----	-------	---------------------	------	---	-------	-------	------	------	-------	------	-------

No. 3.

(*)	195 {	Aug. 22 Sept. 13	} 22	5	16.87	12.10	1.37	3.40	71.73	8.12	20.15
-----	-------	---------------------	------	---	-------	-------	------	------	-------	------	-------

* Unselected.

HONEY DEW.

This variety gives very good canes and plenty of white seed, which, however, is usually all taken by birds. The sugar per cent of the juice is low, the glucose relatively high, and the purity low.

Average of analyses of Honey Dew.

1890.

Parent plot. 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	175 {	Aug. 25 Sept. 23	} 29	6	<i>Pr. cent.</i> 16.85	<i>Pr. cent.</i> 11.47	<i>Pr. cent.</i> 1.35	<i>Pr. cent.</i> 4.03	68.07	8.01	23.92

* Unselected.

CHINESE IMPHEE.

Imphee canes are tall and slender.

Averages of analyses of Chinese Imphee.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	14 {	Sept. 14 Oct. 11	} 27	6	<i>Pr. cent.</i> 18.08	<i>Pr. cent.</i> 13.81	<i>Pr. cent.</i> .61	<i>Pr. cent.</i> 3.66	76.38	3.38	20.24

1890.

14	349 {	Sept. 6 Oct. 3	} 27	4	18.73	14.03	.73	3.97	74.90	3.90	21.20
----------	-------	-------------------	------	---	-------	-------	-----	------	-------	------	-------

* Unselected.

VARIETY NO. 350.

This variety originated from a cross of Link's Hybrid and Orange. The parent cane was selected in 1883, and the seed head planted in lot 350 in 1889.

Averages of analyses of Variety 350.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	350	Oct. 26	1	1	<i>Pr. cent.</i> 21.90	<i>Pr. cent.</i> 15.54	<i>Pr. cent.</i>	<i>Pr. cent.</i>	70.95	.....	.....

1890.

350	60 {	Sept. 8 Oct. 31	} 43	2	21.15	15.83	.94	4.38	74.85	4.44	20.71
----------	------	--------------------	------	---	-------	-------	-----	------	-------	------	-------

VARIETIES NOS. 126 AND 127.

The seed of these two lots came from Australia. They are apparently the same variety. The canes of both are large and handsome. Both show high sugar, low glucose, high nonsugar, and good purity.

Averages of analyses of lots 126 and 127.

1890.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	126	Sept. 9	36	6	<i>Pr. cent.</i> 19.62	<i>Pr. cent.</i> 15.02	<i>Pr. cent.</i> .63	<i>Pr. cent.</i> 3.97	76.56	3.21	20.23
	127	Sept. 9	36	6	20.44	15.42	.41	4.61	75.44	2.01	22.55

VARIETY No. 289.

This variety originated from a cross of White India and Orange. The parent cane was picked out in 1888 and the seed head planted in plot 289 in 1889. The canes are short, sturdy, and strongly rooted. The sugar per cent is very high, the glucose low, and the nonsugar high. The purity is very good.

Averages of analyses of Variety 289.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	289	Oct. 3	1	1	<i>Pr. cent.</i> 19.40	<i>Pr. cent.</i> 15.47	<i>Pr. cent.</i> .59	<i>Pr. cent.</i> 3.34	79.74	3.05	17.21

1890.

289 --	90	Sept. 8	7	3	20.24	15.47	.84	3.93	76.43	4.15	19.42
	91	Sept. 8	35	6	20.79	15.91	.84	4.04	76.52	4.04	19.44
		Oct. 13									
Mean	-----	-----	-----	-----	20.51	15.69	.84	3.98	76.47	4.09	19.43

VARIETY No. 112.

This variety originated in a sport found in a field of Honduras in 1888. The seed head was planted in plot 112 last year. The sugar per cent. is good and the glucose moderately low. The purity is good.

Averages of analysis of Variety No. 112.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	112 {	Sept. 17 Oct. 12	{ 25	7	<i>Pr.cent.</i> 18.62	<i>Pr.cent.</i> 14.23	<i>Pr.cent.</i> 1.08	<i>Pr.cent.</i> 3.31	76.42	5.80	17.78

1890.

112.. {	73 {	Sept. 2 Oct. 2	{ 30	6	18.74	14.30	1.14	3.30	76.31	6.08	17.61
	74 {	Sept. 12 Oct. 13	{ 41	7	17.82	13.25	1.15	3.42	74.35	6.45	19.20
	75 {	Aug. 27 Oct. 3	{ 47	7	17.79	13.09	1.09	3.61	73.59	6.12	20.29
Mean.					18.12	13.55	1.13	3.44	74.75	6.22	19.03

VARIETY No. 110.

This variety originated from a sport found in a field of Honduras in 1888.

Averages of analyses of Variety No. 110.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	110 {	Sept. 17 Sept. 27	{ 10	4	<i>Pr.cent.</i> 17.81	<i>Pr.cent.</i> 14.25	<i>Pr.cent.</i> .76	<i>Pr.cent.</i> 2.80	80.00	4.27	15.73

1890.

110	343 {	Sept. 6 Sept. 12	{ 6	2	18.69	13.89	.94	3.86	74.32	5.03	20.65
----------	-------	---------------------	-----	---	-------	-------	-----	------	-------	------	-------

UNGATUBANDA.

This variety was grown last year only and but one analysis made then. The canes are fairly good.

Ungatubanda.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
	21	Oct. 1	1	1	<i>Pr. cent.</i> 15.93	<i>Pr. cent.</i> 12.17	<i>Pr. cent.</i> .61	<i>Pr. cent.</i> 2.95	76.40	5.08	18.52

DINDEMUKA.

The canes of this variety have each three to five seed heads, which is an undesirable characteristic. The per cent of sugar is fair and that of glucose moderate.

Averages of analyses of Dindemuka.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(1) {	37 {	Oct. 4	} 7	2	<i>Pr. cent.</i> 17.02	<i>Pr. cent.</i> 12.41	<i>Pr. cent.</i> .83	<i>Pr. cent.</i> 3.78	72.92	4.87	22.21
	234 {	Oct. 11									
		Sept. 6	} 50	9	16.52	12.00	1.54	2.98	72.64	9.32	18.04
		Oct. 26									
Mean.	.....	.....	.....	.....	16.77	12.20	1.19	3.38	72.78	7.09	20.13

* Unselected.

1890.

37	187 {	Sept. 13	} 34	4	18.84	13.46	1.47	3.91	71.44	7.80	20.76
		Oct. 7									

EARLY TENNESSEE.

Was grown in 1888 and 1889. It is not a desirable variety, having only early ripening to recommend it. The per cent of sugar is very low and those of glucose and non-sugar both high. It is extremely variable.

Averages of analyses of Early Tennessee.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	102 {	Aug. 21 Aug. 31	} 10	2	Pr.cent. 14.31	Pr.cent. 7.44	Pr.cent. 2.22	Pr.cent. 4.65	52.00	15.52	32.48

* Unselected.

1889.

102....	245 {	Sept. 2 Sept. 9	} 7	4	10.94	5.43	3.29	2.22	49.60	30.10	20.30
---------	-------	--------------------	-----	---	-------	------	------	------	-------	-------	-------

PLANTER'S FRIEND.

This variety came here from Australia, although originally a native of India. It is a handsome cane and gives a good tonnage. As improved by selection it has high sugar, rather high glucose, and about the average "other solids."

Averages of analyses of Planter's Friend.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
(*)	231 {	Sept. 18 Oct. 24	} 36	4	Pr.cent. 18.58	Pr.cent. 12.15	Pr.cent. 1.78	Pr.cent. 4.65	65.39	9.58	25.03

* Unselected.

Averages of analysis of *Planter's Friend*—Continued.

1889.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugar.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
231 --	177	Oct. 2	22	4	<i>Pr.cent.</i>	<i>Pr.cent.</i>	<i>Pr.cent.</i>	<i>Pr.cent.</i>			
		Oct. 24			14.89	9.67	2.44	2.78	64.94	16.38	18.68
	180	Oct. 7	17	2	14.47	9.93	1.55	2.99	68.02	10.71	20.62
		Oct. 24									
	181	Oct. 7	17	2	14.66	9.09	2.54	3.03	62.01	17.32	20.67
		Oct. 24									
	182	Oct. 7	17	3	17.02	11.28	2.55	3.19	66.27	14.98	18.75
		Oct. 24									
	184	Sept. 26	28	5	15.26	9.58	2.99	2.69	62.78	19.58	17.63
		Oct. 24									
	185	Sept. 20	33	7	15.67	9.51	3.16	3.00	60.68	20.17	19.15
		Oct. 23									
	186	Sept. 20	33	9	19.03	14.64	1.47	2.93	76.89	7.72	15.39
		Oct. 23									
	188	Sept. 12	42	5	15.54	9.79	2.78	2.97	63.00	17.89	19.11
		Oct. 24									
	189	Oct. 7	17	3	17.22	11.85	2.30	3.07	68.82	13.35	17.83
		Oct. 24									
	191	Sept. 28	26	5	16.38	10.30	3.12	2.96	62.88	19.04	18.08
		Oct. 24									
	190	Sept. 28	26	5	15.62	9.54	2.78	3.30	61.07	17.80	21.13
		Oct. 24									
	376	Oct. 5	21	5	18.19	12.19	2.28	3.72	67.02	12.53	20.45
		Oct. 26									
Mean					16.16	10.61	2.49	3.06	65.65	15.41	18.94

1890.

186 --	106	Sept. 13	32	6	20.34	14.20	1.88	4.26	69.82	9.24	20.94
		Oct. 15									
	107	Sept. 13	32	6	20.42	14.56	2.10	3.76	71.30	10.29	18.41
		Oct. 15									
	273	Sept. 13	35	6	20.39	14.96	1.66	3.77	73.37	8.14	18.49
		Oct. 18									
Mean					20.38	14.57	1.88	3.93	71.49	9.22	19.28

LIBERIAN.

This is an old and well-known variety. The seed is very small, and the plant in consequence is at first feeble. The sugar per cent is fair, the glucose rather high, and the non-sugar low.

Averages of analyses of Liberian.

1888.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
*	74	Sept. 17 Oct. 9	22	5	<i>Pr.cent.</i> 18.28	<i>Pr.cent.</i> 11.84	<i>Pr.cent.</i> 3.07	<i>Pr.cent.</i> 3.37	64.77	16.79	18.44
	222	Sept. 28 Oct. 5	7	2	18.43	12.34	2.32	3.77	66.96	12.59	20.45
	227	Sept. 20 Sept. 26	6	2	16.57	10.99	2.02	3.56	66.32	12.20	21.48
Mean.	-----	-----	-----	-----	17.76	11.72	2.46	3.58	66.00	13.85	20.16

* Unselected.

1889.

	27	Oct. 8	11	3	19.03	13.00	2.17	3.86	68.32	11.38	20.30
	124	Oct. 19 Sept. 20 Oct. 21	31	5	17.23	11.22	4.11	1.90	65.12	23.86	11.02
	125	Oct. 5	18	3	18.69	14.23	2.79	1.67	76.13	14.93	8.94
	126	Sept. 12 Oct. 23	11	3	18.58	13.00	2.76	2.82	70.00	14.82	15.18
	127	Oct. 5 Oct. 23	18	3	18.46	12.92	2.99	2.55	70.00	16.20	13.80
	128	Oct. 5 Oct. 26	21	4	19.23	13.13	2.62	3.48	68.28	13.62	18.10
	129	Sept. 20 Oct. 26	36	5	18.75	12.69	3.03	3.03	67.68	16.16	16.16
	130	Oct. 5 Oct. 23	18	3	18.51	12.27	3.21	3.03	66.28	17.35	16.37
	133	Oct. 5 Oct. 23	18	3	18.71	11.97	3.03	3.71	63.97	16.20	19.83
	134	Oct. 5 Oct. 23	18	3	18.16	12.88	3.36	1.92	70.92	18.50	10.58
	136	Oct. 10 Oct. 23	13	2	18.06	12.04	3.28	2.74	66.67	18.16	15.17
	138	Oct. 10 Oct. 23	13	2	18.81	11.81	3.54	3.46	62.78	18.82	18.40
	139	Oct. 5 Oct. 23	18	3	18.79	12.91	3.06	2.82	68.71	16.28	15.01
	140	Sept. 26 Oct. 23	27	3	17.97	11.61	3.30	3.06	64.61	18.36	17.03
	141	Oct. 10 Oct. 23	13	2	18.46	13.39	3.10	1.97	72.54	16.79	10.67
	142	Oct. 10 Oct. 23	13	2	17.46	11.15	3.50	2.81	63.86	20.05	16.09
	144	Oct. 5 Oct. 23	18	3	17.89	12.99	2.44	2.46	72.61	13.64	13.75
	145	Oct. 11 Oct. 24	13	2	16.54	10.90	3.48	2.16	65.90	21.04	13.06
	243	Oct. 3 Oct. 25	22	4	17.12	10.22	3.63	3.27	59.70	21.20	19.10
	315	Oct. 5 Oct. 26	21	4	18.00	12.54	3.04	2.42	69.66	16.90	13.44
Mean.	-----	-----	-----	-----	18.22	12.34	3.12	2.76	67.73	17.12	15.15

1890.

	108	Sept. 12 Oct. 4	22	4	18.16	12.30	3.08	2.78	67.33	14.17	18.50
	109	Sept. 2 Oct. 4	32	4	17.74	12.31	2.88	2.55	69.73	12.97	17.30
	131	Sept. 1 Sept. 6	5	2	18.16	12.52	3.16	3.48	69.16	15.04	15.80
Mean.	-----	-----	-----	-----	18.02	12.38	3.04	2.60	68.74	14.06	17.20

ALAPORE JOWAR.

This is a new variety the seed of which was received from India this year. The canes are short and small, with heavy compact seed heads and dark green leaves.

Average of analyses of Alapore Jowar.

Parent plot, 1888-'89.	Plot.	Dates.	Length of season in days.	No. of analyses.	In the juice.				Of the juice.		
					Solids.	Sucrose.	Glucose.	Solids, not sugars.	Purity or sucrose coefficient.	Glucose coefficient.	Non-sugars coefficient.
			22	3	<i>Pr. cent.</i> 17.75	<i>Pr. cent.</i> 12.55	<i>Pr. cent.</i> 0.76	<i>Pr. cent.</i> 4.44	70.70	4.28	25.02

WORK ON CROSSES.

In 1888, 150 plots were planted, each with seeds from a single crossed cane. In 1889, 250 similar plots were planted. In 1890, 355 plots were thus planted, and in all 755 plots were planted with cross-fertilized seeds, and many hundred analyses of the juices of hybrid canes were made to determine the possibility of producing improved varieties of sorghum by hybridization.

It appears that all the varieties can be cross-fertilized, and that a multitude of new varieties can thus be produced.

Not only do varieties which resemble each other and which flower and mature at the same time cross-fertilize, as for instance Kansas Orange and Early Orange, but very dissimilar varieties also cross-fertilize, as for instance, the small and early maturing Early Amber with the larger and later Link's Hybrid.

The principal part of the work has been done on crosses of the following varieties:

- Amber and Orange.
- Amber and Link's Hybrid.
- Amber and White India.
- Orange and White India.
- Orange and White African.
- Orange and Link's Hybrid.
- Link's Hybrid and White India.
- Link's Hybrid and Red Liberian.
- Link's Hybrid and White African.

The first effect of a cross between varieties appears to be simply an alteration in the germs of the seeds which have been fertilized by pollen from another variety. This does not appear to influence or modify in any way the canes which produce the altered seeds. It follows from this that sorghum canes, grown from good seed, planted in close proximity to non-saccharine or inferior varieties produce as good canes for

sugar-making as when planted away from other varieties. But the seeds produced by the canes near inferior canes may be modified in the germs by pollen from the inferior canes, so that the canes produced in the next generation by these seeds may be variable in type, uneven in time of maturing, and inferior in quality.

The varieties of sorghum do not cross so readily as is popularly believed. In many cases at this station thousands of seeds of two varieties have been intentionally mixed and planted together in the hope of obtaining a desired cross. In some cases no crossed plants were produced; in other cases but a few crossed plants were found in the second generation, at which time the effects of cross-fertilization the previous year may be clearly seen. But while varieties of sorghum do not freely intermingle, yet cross-fertilization is effected under favorable conditions, and continuous planting of seeds which may contain but a few crossed seeds results finally in variable and mongrel seeds which produce canes which are uneven in ripening, uneven in sugar content, and not uniform in type.

The first effect observed, when cross-fertilized seeds are planted, is, in many cases, remarkably increased vigor of the crossed plants. The canes produced the first season after the cross-fertilization are often much larger and taller than canes of either of the parent varieties. The seeds and the seed heads are often remarkably large.

In looking over a field of cane it is safe to conclude that those canes which tower above the majority of the canes are crossed canes, or are stray canes from some larger variety. In selecting seed heads from a heap of cane tops, those which are remarkably large and fine it is safe to conclude are from crossed canes or from stray canes of larger varieties.

It follows from this that the common practice of selecting the largest and finest seed heads for planting leads to wrong results in two ways: It is in many cases a selection of seed from crossed and variable canes, which is especially to be avoided, and it is in any case a selection of seed from canes which tend more to grain production than to sugar production, for, as a rule, the largest grain-producing canes have produced less sugar.

The extraordinary vigor, the unusually large growth of cane, the large seeds, and the heavy seed tops are usually found only in canes produced by seeds which were cross-fertilized the season before, that is, in the first generation of canes. In many cases crossing appears to act as a temporary stimulant, the canes in subsequent generations being no more than ordinary size. But there have been cases at this station where seeds cross-fertilized in 1887 produced canes in 1889 and again in 1890 which were larger than the canes of either of the parent varieties.

When cross-fertilized seeds are planted the canes of the first generation usually show remarkable variations in type, many showing an evident approximation to one or other of the parent varieties. In most

cases the departure from the typical character of the parent variety covers the widest range from the least to the greatest variation. The "seedling" canes often differ from any known varieties. When it is remembered that a single seed head usually contains from 500 to 1,000 seeds, and that these seeds may have been cross-fertilized in different degrees, the cause of these variations is partly explained. But it also appears that cross-fertilization also "breaks up" a uniform variety and induces variations in type, and sometimes causes departures from any known types, so that the crossed plants differ in foliage, in habit of growth, in color of seed top, in size, in earliness of maturing, in fiber, and in quality of juice. The variations in form are apparent to the eye; the variations in the quality of the juice are shown by analysis. In the canes produced by one crossed seed head, one may have 8 per cent of sugar, another may have 16 per cent, so that it is often impossible to make comparable analyses by taking samples of canes intended to represent the average value of the plot.

In some cases apparent reversions to some old form or variety are seen in canes produced from one crossed seed head. For instance, it is generally supposed that the Early Amber variety originated in this country. Mr. Leonard Wray, however, insists that he imported it to this country in 1851 under the name Boomvwana, which signifies red. The Amber is a black-seeded variety. In a dozen lots of Amber crosses reversions to a scarlet or bright red variety were seen, a color not derived from either of the parent varieties of these crosses, but probably a reversion to the original color of the Boomvwana variety.

With sorghum, as with other plants, crossing varieties causes variations in size, in type, and in qualities. Unusual qualities are sometimes found in crossed plants, and there are two methods known of producing improved varieties of plants from single crossed plants which have the desired qualities.

The most common method consists in multiplying the selected plant by bud propagation, that is, by bulb or tuber, by suckers, by graft, by runners, layers, or by cuttings. When a plant is thus propagated by bud, the new plant is simply a continuation of the plant from which the bud was derived; no new plant is formed and the plant is multiplied until it becomes a variety, without variations. It is now known that sugar cane occasionally produces seed, and these seeds cross-fertilized have probably produced canes of unusual types, and these canes propagated by bud have perhaps formed the existing varieties of sugar cane. This method of propagation known and used by horticulturists allows at once the production of a uniform and improved variety from a single remarkable plant.

But this method appears not to be available for the production of improved varieties of sorghum, and the second method, propagation by seed, appears to be the only one practicable.

In this method cross-fertilized seeds are planted and from the vary-

ing canes produced by these seeds the cane having the most desirable qualities is selected, the seeds from the selected cane are planted, and selections are again made rejecting all variations, and the selections are repeated each year until the canes become uniform in type and in quality. By this method improved varieties of many plants have been produced, and these varieties reproduce themselves truly and uniformly by seed.

In the effort to produce improved varieties at this station from cross-fertilized seed it has been found that it is possible to produce a cane having unusually desirable qualities by cross-fertilization. That it is possible to select from the varying canes produced by the seeds of the selected cane a single cane which retains the same desired qualities. That it is possible by repeated similar selections to finally produce a new and improved and uniform variety which truly reproduces itself by seed. That in many cases a new and uniform variety is produced from a single crossed cane in 3 years, and then but slight reversions in type or variations in quality can be perceived. That some crosses are more persistent in tendency to reversions to the original types, and require more time to fix the new types, the tendency to reversion becoming less at each selection. That any desired character in form or size of cane, in percentage of sugar or glucose or of "other solids" may be found in the remarkable variations caused by hybridizing varieties, and that these qualities may be fixed by repeated selections from the cross fertilized canes.

This subject has been dwelt upon here, because the work at this station in improving varieties has been more successful in the production of improved varieties from crosses than in finding a superior variety by importation from foreign countries.

CULTURE EXPERIMENTS AT COLLEGE PARK, MARYLAND.

The experiments made in 1889 at College Park were rendered entirely futile by the exceptionally wet season, which prevented planting the cane at the proper time, interfered with its cultivation, and retarded its maturity. Hoping to obtain better results it was decided to continue the work, on a small scale, during the present season. Four acres of land were leased from Mr. D. M. Nesbit, and this land was divided into eight equal portions. The land was in the form of a parallelogram, the length lying east and west and was twice as long as it was wide. An attempt was made to secure land of a perfectly uniform nature, but even in so small a portion as 4 acres this was found to be impossible. The western part of the land was a gravelly loam, while about 1½ acres of its eastern portion was much more sandy and less fertile than the western part.

The eight subdivisions were planted north and south and were numbered by the letters of the alphabet beginning on the west side with plot A and continuing to the east end to plot H, each plot containing half an acre. In an eastern and western direction the plots were divided into five equal portions, and the numerals from 1 to 40 were applied to the small plots made by the crossing of the eight north and south divisions with the five east and west divisions, each plot containing one-tenth of an acre.

The method of plotting the field and the number of each plot are shown in the diagram.

On plots 1, 6, 11, 16, 21, 26, 31, 36, 3, 8, 13, 18, 23, 28, 33, 38, Link's Hybrid was planted; on plots 2, 7, 12, 17, 22, Early Amber; on plots 4, 9, 14, 19, 24, 29, 34, and 39, Undendebule; on plots 27, 32, 37, Red Liberian; on plots 5, 10, 15, and 20, Early Orange; on plots 25, 30, 35, and 40, Improved Orange and two rows of Early Orange to finish out the plot of which there was not enough Improved Orange seed to complete.

The principal object of the experiment was to determine the influence of different kinds of artificial fertilizers on the composition of the cane. The fertilizers employed and the method of distributing are indicated in the following scheme :

		N			
W	1	6	11	16	E
	2	7	12	17	
	3	8	13	18	
	4	9	14	19	
	5	10	15	20	
		S			
		A	B	C	D

Link's Hybrid :

Plots 1, 6, 11, 16, 21, 26, 31, 36,
3, 8, 13, 18, 23, 28, 33, 38.

Early Amber :

Plots 2, 7, 12, 17, 22.

Undendebule :

Plots 4, 9, 14, 19, 24, 29, 34, 39.

		N			
W	21	26	31	36	E
	22	27	32	37	
	23	28	33	38	
	24	29	34	39	
	25	30	35	40	
		S			
		E	F	G	H

Red Liberian :
Plots 27, 32, 37.

Early Orange :
Plots 5, 10, 15, 20.

Improved Orange :
Plots 25, 30, 35, 40.

Scheme for distributing fertilizers.

- 1.....Cotton-seed meal.
- 2.....Superphosphate.
- 3.....Kainite.
- 4.....Nitrate of soda.
- 5.....(1, 2, and 3) equal portions of each.
- 6.....(2, 3, and 4) equal portions of each.

- On A.....No. 5.
 On B.....No. 2.
 On C.....Nothing.
 On D.....No. 3.
 On E.....No. 4.
 On F.....Nothing.
 On G.....No. 6.
 On H.....No. 1.

Basis of application.

[Pounds per acre.]

No. 1.....	600	No. 4.....	400
No. 2.....	600	No. 5.....	600
No. 3.....	600	No. 6.....	600

In regard to taking samples for analysis the following plan was pursued :

Beginning, for instance, with the Early Amber, which was the first to ripen, samples of the cane were taken by cutting about one hundred canes of Early Amber from each of the different lettered plots on which it was planted, viz, A, B, C, D, and E. These canes were thrown together, well mixed, and divided into four parts, and one part sent to the laboratory for analysis. In this way samples were taken from each of the plots under the influence of each kind of fertilizer on the same day. On September 11, five samples of Early Amber were sent to the laboratory for analysis, including one sample from each of the lettered plots on which the Amber was grown. On the 19th, 24th, and 30th of September and 3d and 10th of October samples were taken in the same way from each of the plots of Amber. The other varieties were treated in the same way when they approached maturity, the object being to secure a study of the characteristics of the cane at about that period at which it would be used for manufacturing purposes if grown on a large scale.

The character of the cane was disappointing, with the exception of the Early Amber, indicating a crop which would have been unprofitable for manufacturing purposes.

With the exception of the Early Amber the growth of cane was luxuriant on all the plots except those at the extreme eastern end, in the poor ground. The Early Amber, as is usual with this variety, was very small as compared with the other varieties, and yet the yield per

acre was fair. The mean analyses of the Early Amber variety for the different plots are as follows :

	A	B	C	D	E
Total solids.....per cent..	17.5	17.7	17.1	16.7	16.0
Sucrose.....do....	13.4	13.1	12.9	12.1	11.4
Glucose.....do....	1.3	1.7	1.8	2.2	2.5
Purity.....do....	76.5	73.9	75.0	72.5	71.0

The analyses of the Early Orange were commenced on the 20th of September; subsequent sets of samples were examined on the 1st, 4th, 13th, 18th, and 30th of October. The mean results were as follows:

	A	B	C	D	E	F	G	H
Total solids, per cent.	14.5	15.3	15.0	14.5	15.5	15.3	15.2	16.1
Sucrose.....do....	7.7	8.9	8.4	8.1	9.9	9.7	9.7	10.6
Glucose.....do....	4.8	4.6	4.5	4.8	4.1	4.2	4.1	4.0
Purity.....do....	53.1	57.3	56.1	55.0	64.1	63.0	63.7	64.5

The analyses of Link's Hybrid were commenced on the 22d of September and continued on the 25th and 29th of September and the 6th, 11th, and 29th of October. The mean results obtained were as follows:

	A	B	C	D	E	F	G	H
Total solids, per cent.	14.6	14.9	14.4	14.3	15.8	15.1	14.7	15.9
Sucrose.....do....	10.2	9.5	8.9	9.8	11.8	10.1	10.7	11.3
Glucose.....do....	2.2	3.1	3.9	2.7	1.8	2.8	2.3	2.2
Purity.....do....	69.9	64.5	61.4	68.3	74.8	66.5	72.8	71.5

The analyses of Undendebule were commenced on the 26th of September and continued on the 2d, 17th, and 25th of October. The mean results obtained follow:

	A	B	C	D	E	F	G	H
Total solids, per cent.	13.5	14.2	14.6	15.0	15.9	15.6	16.3	16.1
Sucrose.....do....	9.3	8.9	9.1	11.3	11.2	10.2	11.4	10.9
Glucose.....do....	2.4	3.3	3.3	2.1	2.2	2.8	2.6	2.4
Purity.....do....	68.4	62.3	62.4	75.3	74.0	65.1	69.6	67.6

The analyses of Improved Orange were commenced on the 16th of October and continued on the 21st and 27th. Following are the means obtained:

	E.	F.	G.	H.
Total solids.....per cent..	15.8	15.3	15.4	15.6
Sucrose.....do....	11.3	10.9	10.7	10.7
Glucose.....do....	3.5	4.2	4.0	4.0
Purity.....do....	71.1	71.3	70.0	68.5

Analyses of Red Liberian were commenced on the 15th of October and continued on the 20th and 28th. Following are the mean results obtained :

	F.	G.	H.
Total solids per cent..	14.4	14.5	15.2
Sucrose do.....	3.9	4.5	5.2
Glucose do.....	6.6	6.5	6.2
Purity do.....	26.8	30.4	33.9

In order to obtain a comparison in richness of sugar of the results on all the different plots with the different kinds of fertilizers, the following tabular arrangement has been constructed. Taking the mean results of each variety, they have been arranged in the following order :

First, in the order of highest sucrose ; the plot giving, for instance, the highest sucrose being placed first and those containing the next subsequent percentages in order below. For instance, in the case of Early Amber, it was found that the highest sucrose was in plot A and there is a regular decrease from plot A, so that this was arranged in alphabetical order, A, B, and so on. In the next group are contained the plots with the lowest glucose, beginning with the lowest and continuing to the highest. In the next group are collected the mean purities, beginning with the highest purity and continuing to the lowest purity in order.

Classification of plots in respect of sucrose, glucose, and purity.

Variety.	Highest sucrose.								Lowest glucose.								Highest purity.							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Early Amber	A	B	C	D	E	...	...	...	A	B	C	D	E	...	...	...	A	C	B	D	E	...	...	...
Early Orange	H	E	F	G	B	C	D	A	H	G	A	E	C	D	B	A	H	E	G	H	F	C	D	A
Link's Hybrid ..	E	H	G	A	F	D	B	C	E	H	A	G	F	B	C	E	H	G	A	F	D	B	C	E
Undendebule	G	D	E	H	F	A	C	B	D	E	A	G	H	F	B	C	D	E	H	F	A	C	B	D
Improved Orange ..	E	F	G	H	...	...	...	...	E	F	G	H	...	...	...	...	F	G	H	...	...	...	...	...
Red Liberian	H	G	F	...	...	...	...	...	H	G	F	...	...	...	...	...	H	G	F	...	...	...	...	...

An analysis of this table shows that the plots have the following relations:

Plots.	Rank.								Total.
	1	2	3	4	5	6	7	8	
A.....	3	1	1	3	0	1	0	3	12
B.....	0	2	1	0	2	1	4	2	12
C.....	0	1	2	0	1	2	2	4	12
D.....	2	1	0	3	2	1	3	0	12
E.....	5	4	2	0	1	0	0	0	12
F.....	1	2	4	2	2	4	0	0	15
G.....	1	5	6	2	1	0	0	0	15
H.....	6	1	2	4	1	0	0	0	14

Per cent:

A for first place	25.0
B for first place	00.0
C for first place	00.0
D for first place	16.7
E for first place	42.7
F for first place	8.3
G for first place	8.3
H for first place	50.0

Multiplying each rank of each plot by the number of times it occurs and dividing by 8 will give the mean position of each plot in the series.

A = 6.25	E = 3.00
B = 8.37	F = 7.38
C = 8.63	G = 5.30
D = 6.63	H = 4.38

In reviewing these results the following facts are noticed: With Early Amber the highest sucrose was produced by fertilizer 5, followed in order by 2, 0, 3, and 4. The lowest glucose appears in same order.

The highest purity was found with No. 5, followed by 0, 2, 3, and 4.

With Early Orange the highest sucrose was produced with No. 4, followed in order by 2, 0, 3, and 5.

The lowest glucose was found with No. 4, followed by Nos. 0, 2, 3, and 5.

The highest purity was found with No. 4, followed in order by Nos. 2, 0, 3, and 5.

The above comparison, however, is not strictly just on account of the fact that all varieties were not planted on all the plots. It will be better, therefore, to compare only those plots and varieties which present a complete comparison. These plots are A, B, C, D, and E, and the varieties Early Amber, Early Orange, Link's Hybrid, and Undendebule.

Classification of plots A, B, C, D, and E, with varieties Early Amber, Early Orange, Link's Hybrid, and Undendebule.

Variety.	Highest sucrose.					Lowest glucose.					Highest purity.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Early Amber	A	B	C	D	E	A	B	C	D	E	A	C	B	D	E
Early Orange	E	B	C	D	A	E	C	B	D	A	E	B	C	D	A
Link's Hybrid	E	A	D	B	C	E	A	B	D	C	E	A	D	B	C
Undendebule	D	E	A	C	B	D	E	A	B	C	D	E	A	C	B

With Link's Hybrid the highest sucrose was found with No. 4, followed in order by Nos. 5, 3, 2, and 0.

The lowest glucose was found with No. 4, followed in order by Nos. 5, 2, 3, and 0.

The highest purity was found with No. 4, followed in order by Nos. 5, 3, 2, and 0.

With Undendebule the highest sucrose was found with No. 3, followed in order by Nos. 4, 5, 0, and 2.

The lowest glucose was found with No. 3, followed in order by Nos. 4, 5, 2, and 0.

The highest purity was found with No. 3, followed in order by Nos. 4, 5, 0, and 2.

A general comparison of the numbers is given in the following table:

Plot.	Rank.					Total.
	1	2	3	4	5	
A	3	3	3	0	3	12
B	0	4	3	3	2	12
C	0	2	4	2	4	12
D	3	0	2	7	0	12
E	6	3	0	0	3	12

Multiplying the times each plot occurs in the series by the number of the rank and dividing by 5 we obtain the mean position of each plot.

$$\begin{array}{ll}
 1 \text{ E} = 5.4 & 4 \text{ B} = 7.8 \\
 2 \text{ A} = 6.6 & 5 \text{ C} = 8.8 \\
 3 \text{ D} = 7.4 &
 \end{array}$$

Hence it appears that in general results nitrate of soda (fertilizer applied to plot E) has produced the most favorable effects. Followed by this is a mixture of equal parts of cotton-seed meal, superphosphate, and kainite. Next in order comes kainite alone. In the next rank we find superphosphate alone; while the plot C, which received no fertilizer at all, showed the poorest results.

These data are more valuable in indicating the methods of studying the effects of intensive culture on sorghum than for the definite knowledge obtained. It is evident at once that only several years of continual investigation would make a solution of the problem possible.

The agricultural data are briefly given in the following résumé:

Plots A, B, C, and part of D were rather light soil, containing a large percentage of sand and having perfect natural drainage; the remainder of the plots were more clayey and compact. The light soil favored the growth of sorghum so that it matured on an average one month earlier than that in the other plots. It is worthy of note that the sorghum showed far greater sensitiveness to difference in soils than a field of corn grown next to it on the same kind of ground. The following statement gives the number of stalks per acre, and the gross weight per acre, including the blades and seed heads, and the net weight per acre including only the clean cane for each variety on the different plots. These weights were all taken on the same day, viz, the 15th of October, 1890, and the weight per acre is based upon a carefully meas-

ured portion of each plot, the whole of which was harvested and weighed in the manner indicated :

Plots.	Link's Hybrid.			Early Amber.			Undendebule.		
	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.
		<i>Pounds.</i>	<i>Pounds.</i>		<i>Pounds.</i>	<i>Pounds.</i>		<i>Pounds.</i>	<i>Pounds.</i>
A	22,000	23,500	17,500	20,000	15,000	12,000	23,000	32,000	27,500
B	27,000	29,500	21,500	21,000	10,000	7,500	18,000	27,500	21,500
C	15,000	23,000	17,000	18,000	7,500	6,300	27,000	29,000	21,000
D	21,000	36,000	26,500	18,000	12,500	9,000	23,000	20,000	14,000
E	24,000	37,000	27,000	18,000	6,000	4,500	21,000	22,500	16,500
F	25,000	32,500	24,500	.....	.....	.....	21,000	24,000	16,500
G	21,000	25,500	19,000	.....	.....	.....	17,000	21,500	15,000
H	23,000	28,500	19,500	.....	.....	.....	20,000	22,000	15,000

Plots.	Early Orange.			Improved Orange.			Red Liberian.		
	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.
		<i>Pounds.</i>	<i>Pounds.</i>		<i>Pounds.</i>	<i>Pounds.</i>		<i>Pounds.</i>	<i>Pounds.</i>
A	18,000	33,000	25,500	.....	.....	.....	.....	.....	.....
B	21,000	27,500	22,200	.....	.....	.....	.....	.....	.....
C	20,000	22,000	17,000	.....	.....	.....	.....	.....	.....
D	18,000	27,500	21,000	.....	.....	.....	.....	.....	.....
E .....	.....	.....	.....	17,000	13,500	10,000	.....	.....	.....
F .....	.....	.....	.....	18,000	14,500	10,500	21,000	30,000	23,000
G .....	.....	.....	.....	18,000	17,000	11,500	22,000	24,500	19,500
H .....	.....	.....	.....	17,000	18,000	13,000	14,000	22,500	16,500

The analytical data follow :

Analyses of sorghum from College Park, Prince George's County, Maryland.

Variety.	Plot.	Serial No.	When received.	In the juice.			
				Solids.	Sacrose.	Glucose.	Purity.
Early Amber	A	7430	Sept. 11	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
		7435	Sept. 19	16.8	12.7	1.79	75.6
		7452	Sept. 24	18.2	13.8	1.20	75.8
		7469	Sept. 30	18.1	13.7	1.37	75.7
		7481	Sept. 30	18.0	13.8	1.47	76.7
		7481	Oct. 3	17.7	13.4	1.16	75.7
		7492	Oct. 10	16.4	13.0	1.30	79.3
				17.5	13.4	1.38	76.5
Early Amber	B	7431	Sept. 11	16.7	11.9	2.54	71.2
		7436	Sept. 19	17.8	13.5	1.53	75.9
		7453	Sept. 24	18.5	14.0	1.84	75.7
		7470	Sept. 30	17.8	13.1	1.79	73.6
		7482	Oct. 3	17.5	12.9	1.26	73.1
		7493	Oct. 10	17.8	13.2	1.28	74.1
				17.7	13.1	1.71	73.9
Early Amber	C	7432	Sept. 11	16.6	11.8	2.67	71.1
		7437	Sept. 19	16.8	12.8	1.72	76.2
		7454	Sept. 24	18.3	14.3	1.44	78.2
		7471	Sept. 30	17.2	13.0	2.04	75.6
		7483	Oct. 3	17.1	12.7	1.06	74.2
		7494	Oct. 10	16.8	12.5	1.93	74.5
				17.1	12.9	1.81	75.0
Early Amber	D	7433	Sept. 11	15.6	10.5	3.62	67.3
		7438	Sept. 19	16.2	11.4	2.09	70.3
		7455	Sept. 24	17.9	13.3	2.18	74.3
		7472	Sept. 30	16.6	12.2	2.44	73.5
		7484	Oct. 3	16.7	12.3	1.16	73.9
		7495	Oct. 10	17.0	12.9	1.86	75.8
				16.7	12.1	2.23	72.5

Analyses of sorghum from College Park, Prince George's County, Maryland—Continued.

Variety.	Plot.	Serial No.	When received.	In the juice.			
				Solids.	Sucrose.	Glucose.	Purity.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Early Amber.....	E	7434	Sept. 11	15.6	10.5	3.40	67.3
		7439	Sept. 19	15.2	9.9	2.45	65.1
		7456	Sept. 24	16.9	12.7	2.10	75.2
		7496	Oct. 10	16.2	12.4	2.10	76.5
				16.0	11.4	2.51	71.0
Early Orange.....	A	7440	Sept. 20	14.8	6.1	6.67	41.2
		7473	Oct. 1	14.3	7.3	4.81	51.0
		7485	Oct. 4	15.5	9.0	4.59	58.0
		7501	Oct. 13	13.5	8.9	3.81	65.9
		7528	Oct. 18	14.2	7.0	4.31	49.3
				14.5	7.7	4.84	53.1
Early Orange.....	B	7441	Sept. 20	15.2	6.9	6.02	43.4
		7474	Oct. 1	15.9	9.9	4.25	62.3
		7486	Oct. 4	15.5	8.9	4.85	57.4
		7502	Oct. 13	14.5	8.9	4.20	61.3
		7529	Oct. 18	15.4	9.7	3.57	62.3
				15.3	8.9	4.58	57.3
Early Orange.....	C	7442	Sept. 20	15.8	8.4	5.26	53.1
		7475	Oct. 1	14.3	8.6	4.50	60.1
		7487	Oct. 4	15.1	8.7	4.10	57.6
		7530	Oct. 18	14.8	7.9	4.23	53.4
				15.0	8.4	4.52	56.1
Early Orange.....	D	7443	Sept. 20	12.3	4.7	6.10	38.2
		7476	Oct. 1	14.5	7.8	4.74	33.8
		7504	Oct. 13	15.5	10.3	4.50	66.4
		7531	Oct. 18	15.8	9.7	3.84	61.4
				14.5	8.1	4.79	55.0
Early Orange.....	E	7505	Oct. 13	16.3	10.4	4.39	63.8
		7509	Oct. 14	14.9	10.2	3.73	69.0
		7532	Oct. 18	15.8	10.3	3.97	65.2
		7572	Oct. 30	15.1	8.8	4.10	58.3
				15.5	9.9	4.05	64.1
Early Orange.....	F	7506	Oct. 13	15.9	10.0	4.42	62.8
		7510	Oct. 14	14.5	10.6	4.13	73.1
		7533	Oct. 18	15.4	8.6	4.06	55.8
		7573	Oct. 30	15.3	9.4	4.10	60.4
				15.3	9.7	4.18	63.0
Early Orange.....	G	7507	Oct. 13	15.5	10.1	4.34	65.1
		7511	Oct. 14	14.3	9.6	3.84	67.1
		7534	Oct. 18	16.4	10.6	3.84	64.6
		7574	Oct. 30	14.5	8.4	4.20	57.9
				15.2	9.7	4.05	63.7
Early Orange.....	H	7508	Oct. 13	15.9	10.7	4.16	61.0
		7512	Oct. 14	14.9	9.8	4.10	65.8
		7535	Oct. 18	16.6	10.7	3.70	64.5
		7575	Oct. 30	16.8	11.2	4.00	66.7
				16.1	10.6	3.99	64.5
Link's Hybrid.....	A	7444	Sept. 22	14.8	10.4	2.25	70.3
		7457	Sept. 25	13.9	9.3	2.23	66.9
		7465	Sept. 29	13.7	9.3	2.19	67.9
		7488	Oct. 6	13.5	8.9	2.50	65.9
		7497	Oct. 11	15.1	10.9	2.22	74.0
		7566	Oct. 29	16.5	12.3	1.87	74.6
				14.6	10.2	2.21	69.9
Link's Hybrid.....	B	7445	Sept. 22	15.4	10.3	2.85	66.8
		7458	Sept. 25	14.9	9.2	3.47	61.7
		7466	Sept. 29	14.1	8.9	3.03	63.1
		7489	Oct. 5	14.1	9.0	2.97	63.8
		7498	Oct. 11	15.3	10.3	2.96	67.3
				14.9	9.5	3.05	64.5

Analyses of sorghum from Collage Park, Prince George's County, Maryland—Continued.

Variety.	Plot.	Serial No.	When received.	In the juice.			
				Solids.	Sucrose.	Glucose.	Purity.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Link's Hybrid	C	7446	Sept. 22	14.1	8.3	3.33	58.8
		7459	Sept. 25	13.7	7.7	3.54	56.2
		7467	Sept. 29	14.9	9.1	3.54	61.1
		7490	Oct. 6	14.1	8.6	3.45	60.9
		7499	Oct. 11	15.7	9.9	3.65	63.0
		7567	Oct. 29	13.9	9.5	3.35	68.4
				14.4	8.9	3.48	61.4
Link's Hybrid	D	7447	Sept. 22	14.3	9.1	3.06	63.6
		7460	Sept. 25	13.7	9.0	2.77	65.7
		7468	Sept. 29	14.3	8.9	3.33	62.2
		7491	Oct. 6	14.3	10.0	2.17	69.9
		7500	Oct. 11	15.1	10.9	2.82	72.3
		7568	Oct. 29	13.9	10.6	2.12	76.3
				14.3	9.8	2.71	68.3
Link's Hybrid	E	7448	Sept. 22	15.2	10.7	1.97	70.4
		7543	Oct. 22	16.1	11.6	2.08	72.0
		7547	Oct. 24	15.4	12.0	1.85	77.9
		7569	Oct. 29	16.5	13.0	1.41	78.8
				15.8	11.8	1.83	74.8
Link's Hybrid	F	7449	Sept. 22	14.8	9.1	3.27	61.4
		7544	Oct. 22	15.0	10.3	2.66	68.6
		7548	Oct. 24	15.5	10.8	2.59	69.6
				15.1	10.1	2.84	66.5
Link's Hybrid	G	7450	Sept. 22	15.4	10.5	2.63	68.1
		7545	Oct. 22	14.5	10.9	2.07	75.2
		7549	Oct. 24	14.6	10.8	2.24	73.9
		7570	Oct. 29	14.3	10.7	2.17	74.0
				14.7	10.7	2.28	72.8
Link's Hybrid	H	7451	Sept. 22	16.4	11.3	2.61	68.9
		7546	Oct. 22	15.8	11.1	2.14	70.2
		7550	Oct. 24	16.3	11.8	2.03	72.4
		7571	Oct. 29	14.9	11.1	2.10	74.5
				15.9	11.3	2.23	71.5
Undendebule	A	7461	Sept. 26	13.6	9.7	1.94	71.3
		7477	Oct. 2	12.2	7.8	2.82	63.9
		7520	Oct. 17	12.7	7.9	2.17	62.2
		7551	Oct. 25	15.5	11.8	2.46	76.1
				13.5	9.3	2.35	68.4
Undendebule	B	7462	Sept. 26	14.4	8.6	3.29	59.7
		7478	Oct. 2	13.5	7.8	3.59	57.8
		7521	Oct. 17	13.4	7.9	3.38	59.0
		7552	Oct. 25	15.6	11.3	2.96	72.5
				14.2	8.9	3.30	62.3
Undendebule	C	7463	Sept. 26	14.0	8.8	2.99	61.9
		7479	Oct. 2	13.9	7.9	3.70	56.8
		7522	Oct. 17	15.0	9.4	3.33	62.7
		7553	Oct. 25	15.4	10.4	3.22	67.3
				14.6	9.1	3.31	62.4
Undendebule	D	7464	Sept. 26	15.0	11.1	1.94	74.0
		7480	Oct. 2	14.5	10.9	2.04	75.2
		7523	Oct. 17	15.0	11.6	2.08	77.3
		7534	Oct. 25	15.4	11.5	2.19	77.4
				15.0	11.3	2.06	75.3
Undendebule	E	7524	Oct. 17	15.6	11.0	2.01	70.5
		7555	Oct. 25	16.2	11.4	2.37	70.3
				15.9	11.2	2.19	70.4

Analyses of sorghum from College Park, Prince George's County, Maryland—Continued.

Variety.	Plot.	Serial No.	When received.	In the juice.			
				Solids.	Sucrose.	Glucose.	Purity.
Undendebule	F	7525	Oct. 17	<i>Per cent.</i> 15.0	<i>Per cent.</i> 9.8	<i>Per cent.</i> 3.22	65.3
		7556	Oct. 25	16.2	10.5	2.38	64.8
				15.6	10.2	2.40	65.1
Undendebule	G	7526	Oct. 17	16.2	11.5	2.32	71.0
		7557	Oct. 25	16.4	11.2	2.96	68.2
				16.3	11.4	2.64	69.6
Undendebule	H	7527	Oct. 17	16.1	11.2	2.32	69.6
		7558	Oct. 25	16.0	10.5	2.46	65.6
				16.1	10.9	2.39	67.6
Improved Orange	E	7516	Oct. 16	15.2	10.8	4.16	71.1
		7539	Oct. 21	16.0	11.4	3.70	71.2
		7559	Oct. 27	16.3	11.6	3.49	71.1
				15.8	11.3	3.78	71.1
Improved Orange	F	7517	Oct. 16	14.0	10.2	4.20	72.9
		7540	Oct. 21	15.8	11.3	4.31	71.5
		7560	Oct. 27	16.1	11.2	3.97	69.5
				15.3	10.9	4.16	71.3
Improved Orange	G	7518	Oct. 16	15.0	10.7	3.73	71.3
		7541	Oct. 21	15.8	10.7	4.23	67.7
		7561	Oct. 27	15.3	10.8	4.00	70.6
				15.4	10.7	4.00	70.0
Improved Orange	H	7519	Oct. 16	15.0	10.3	4.10	68.7
		7542	Oct. 21	16.0	10.9	4.23	68.1
		7562	Oct. 27	15.7	10.8	3.67	68.7
				15.6	10.7	4.00	68.5
Red Liberian	F	7513	Oct. 15	14.2	4.5	6.17	31.7
		7536	Oct. 20	14.2	3.4	6.76	23.9
		7563	Oct. 28	14.9	3.7	6.94	24.9
				14.4	3.9	6.62	26.8
Red Liberian	G	7514	Oct. 15	14.2	4.0	6.41	28.2
		7537	Oct. 20	14.8	4.9	6.10	33.1
		7564	Oct. 28	15.0	4.5	7.04	30.0
				14.5	4.5	6.52	30.4
Red Liberian	H	7515	Oct. 15	15.0	5.7	5.95	38.0
		7538	Oct. 20	15.0	4.7	6.17	31.3
		7565	Oct. 28	15.7	5.1	6.41	32.5
				15.2	5.2	6.18	33.9

EXPERIMENTS AT THE MISSISSIPPI AGRICULTURAL EXPERIMENT STATION, STARKVILLE, MISSISSIPPI.

Quite a number of the seed heads selected at the Sterling Station in 1889 were sent to the director of the Mississippi Agricultural Experiment Station, Prof. S. M. Tracy, with the request that he coöperate with the Department in testing the value of the different varieties sent in the soil and climate of Mississippi. The cultivation of the samples was undertaken solely at the expense of the Mississippi Station, and in the analyses the Department of Agriculture furnished only the hand mill which was used in expressing the juice from the canes. The analyses were made by Mr. L. G. Patterson, the chemist of the experiment station. A review of the analytical data obtained strongly illustrates the statement which has already been made that the production of a superior variety of cane by selection in one locality will not always insure the development of similar canes from seeds which are planted at a great distance from the original station, where the conditions of soil and climate are quite unlike those under which the standard variety of cane has been developed.

In a variety of Red Liberian No. 137, coming from a cane whose juice showed a content of total solids equal to 19 per cent, analyses were made at the Starkville Station beginning September 1 and running to September 10, in which the content of sucrose in the juice of the cane varied from nothing to 4.9 per cent, while the glucose varied from 5 to 7.45 per cent. The mean numbers were sucrose, 3.0 per cent; glucose, 6.07 per cent. It seems hardly possible that a selected seed head could deteriorate so rapidly in being removed to a different locality. Analyses were continued with this variety planted from a seed head from plot No. 138 of the 1889 Sterling number, showing 18° Brix; No. 125 with a sucrose content of 15.04 per cent; No. 135, showing 18° Brix and No. 125 bis with 14.81 per cent of sucrose. These experiments were continued from September 1 to October 2, but in no case was the result comparable with the character of the parent cane. The percentage of glucose was almost uniformly higher than that of sucrose, and the result of the experiments with this series of selected seed heads was a record of most remarkable deteriorations. In several cases the polariscope failed to reveal any sucrose whatever present in the juices of the cane.

The mean percentages obtained in the juice were as follows:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
138.....	12.2	4.8	4.6
125.....	12.2	4.2	4.7
135.....	11.8	4.3	4.8
125 bis.....	14.1	6.0	4.8

Experiments were also made with selected seed heads from the Undendebule variety of cane selected at Sterling last year and of the following descriptions: Plot No. 297 of 18° Brix; No. 31, of 21° Brix; No. 31, of 20° Brix; No. 254, of 15.53 per cent sucrose. These analyses were commenced on the 2d of October, and continued until the 4th of October. In many cases good results were obtained, but in no case was the parent cane excelled. With stalks produced from seed-head plot No. 254, analyzed on the 3d of October, the sample was found to contain 15.2 per cent of sucrose and 0.54 per cent of glucose, and showing 20° Brix. Many of the other analyses showed fairly good percentages, but the mean of all of them would indicate a general deterioration in the most marked degree from the parent canes. Seed head from plot 31, 21° Brix, is a partial exception.

The mean results follow:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
297.....	12.0	6.4	1.7
31.....	18.3	13.1	1.4
31 bis.....	12.1	6.7	2.0
254.....	15.6	10.5	1.3

Analyses of the variety Rio Blanco were made on October 4. The samples were taken from canes grown from seed head from plot 107, of 21° Brix, and from seed-head plot 107, of 20° Brix. The results here also showed the most remarkable deterioration. In no case did the Brix of the samples grown equal that of the parent cane.

The means were as follows:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
107.....	13.3	7.8	3.8
107 bis.....	15.2	9.2	3.5

Experiments were also made with the India and Orange variety from Sterling, plot 289 of 1889, showing 21° Brix, and from selected seed head 14,175 of India and Orange, showing a sucrose content of 16.42 per cent, the experiments having been made on the 4th and 6th of October. In these cases, also, there was a marked deterioration. In the case of the canes developed from seed head No. 14,175, the highest percentage of sucrose reached was 13, with a glucose content of 1.73 per cent and 18° Brix. This was on the 6th of October. The lowest sucrose content was 4.2 per cent. The average is far below the

percentage of sucrose in the original cane, which, as before stated, was 16.42. Means:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
289	14.7	9.6	2.9
14, 175.....	15.9	10.1	2.8

Experiments made with a variety of Honduras, grown from seed head 12,677, with a sucrose content of 16.72 per cent, showed the same reversion, only in a much more marked degree.

Experiments with Sorghum Bicolor, seed head No. 13,799, with a sucrose content of 13.25 per cent, also failed to develop as rich a cane as the parent, the highest percentage of sucrose found being 12.2, with a percentage of glucose of 0.83 u. c. means.

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
13, 799.....	14.3	8.4	1.1

Experiments were made on the 11th of October with Link's Hybrid variety, from plot 194, seed head 11,586, with a sucrose content of 16.01 per cent. The results also were very poor, the highest sucrose content obtained being 10.3 per cent. Means:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
194.....	14.7	7.6	4.3

Red Liberian, examined on the 11th of October, from seed head No. 13,631, showing a sucrose content of 13.52 per cent, gave somewhat better results than the same variety examined earlier in the season, the highest sucrose found being 11 per cent. From the same variety, seed head 13,655, showing 13.97 per cent sucrose, the results were poorer, the highest sucrose content found being 9.1 per cent.

The means were:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
13, 631.....	14.4	8.5	1.9
13, 655.....	13.7	6.2	4.5

From a cross of Amber and Orange, seed head 13,927 having a sugar content of 16.85 per cent, much better results were obtained. The examination was made on the 17th of October. The percentages of su-

crose obtained in the samples examined on that day were as follows: 15.1, 13.6, 14.2, 11.9, 13.5, 13.5, 11.9, 14.1, 13.7, and 12.9.

The percentages of glucose in all except three instances fell below 1, while the purities were very high. This sample appears to have given the best and most uniform results of any examined during the season.

The mean data are:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
13, 927	17.6	12.5	0.75

On the 18th of October analyses were made of Link's Hybrid again from seed head 11,491, showing a sucrose content of 16.69 per cent, the results being also favorable. The percentages of sucrose were 13.8, 15, 12.6, 13.4, and 14.3, the glucose averaging about 1 per cent, and the purity being high. Analyses of the same plot, continued on the 20th of October, showed results equally good. The means for the two days are:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
11, 491.....	18.4	13.6	1.2

Samples of Link's Hybrid, from seed head 13,897 with a sucrose content of 15.66 per cent, analyzed on the 20th of October, gave less favorable results, the highest sucrose content found being 14.5 per cent, and the lowest 8.8 per cent. Samples from another plot, grown from seed head 11,558, showing a sucrose content of 16.21 per cent, gave still less favorable results, and the same is true of another plot grown from seed heads Nos. 13,379 and 11,585. The means are:

Plot No.	Totalsolids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
13, 897.....	17.0	11.6	1.5
11, 558.....	15.0	9.6	1.8
13, 379.....	15.1	9.5	2.4

Red Liberian examined later in the season, namely, on October 29, still showed the same extremely poor characteristics as were manifested in the earlier part of the season, with the exception of canes grown from seed head from plot 127, showing Brix 19.5°. The means from this plot were:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
127.....	19.5	14.6	1.2

The analyses were completed on the 31st of October by the examination of a sample of a cross of Amber and Orange from seed head No. 12,142 with a sucrose content of 17.99 per cent. In the three samples examined the sucrose was 15.0, 12.5, and 13.8 per cent, and the glucose 1.01, 2.17, and 1.72 per cent, and the Brix 19.5°, 18.0°, and 18.0° Means:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
12, 142	18.5	13.8	2.0

In general, it may be said that the Red Liberian, which has done fairly well in Kansas, was a total failure in Mississippi with the exception of one plot. The same is true but in a less degree of the Undendebule, although some analyses of this last variety were quite favorable, but the average of them all will show a much lower percentage of sucrose than in Kansas. Rio Blanco, which is a kind of Orange cane, also did very poorly in Mississippi, and the same is true of the cross of India and Orange. The Honduras in Mississippi, as elsewhere, has shown itself to be a worthless cane for sugar purposes. Sorghum bicolor also did poorly in Mississippi. The best results obtained were from the cross of Amber and Orange, the one plot of Red Liberian, and Undendebule from plot 254, seed head 13336, of which the mean analyses showed:

Plot No.	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
254.....	18.7	14.8	0.57

This brief review of the data obtained at the Mississippi station tends to show that if sorghum sugar culture is to become a success in that locality it will be quite necessary that a line of experiments in seed selection should be carried on similar to those which have produced such excellent results in Kansas. There is every reason to believe that by the pursuit of the same policy all the standard varieties of cane might be developed which would be as suitable to the soil and climate of Mississippi as those which have been developed in Kansas are to the meteorological conditions of that locality. Still, it must not be forgotten that the general tendency of the researches of the Department has been to show that sorghum does better in a semi-arid locality, and that therefore we ought not to expect as high a development in sugar-producing qualities in Mississippi as can be obtained in more arid regions.

CHARACTERISTICS OF THE SEASON

The season presented no special character until September, when rains became very frequent. From the average record of the weather during the growing season it will be noticed that there were 15 days of

rain in September and only 5 in October. It will be noticed also from the data of analyses which are appended that the sugar content of the juice was very low during the rainy season in September, and during October the sugar content rose rapidly until, in some cases, it reached almost as high a point as in Kansas.

The cane was planted in very rich creek bottom and no fertilizers were employed. In all, 235 plots were planted. The canes were thinned out in the early part of cultivation until they were left about 1 foot apart in the rows.

In taking samples 10 average stalks were selected, the juice expressed from them, and the analyses made thereon.

The record of the observer of the Signal Office for the period of growth follows:

United States Signal Service summary for 1890.

[Place of observation: Agricultural College, county of Oktibbeha, State of Mississippi. Latitude 33°, 26', 30". Longitude 88. Height of ground above sea, 422.4 feet.]

	Monthly mean temperature.	Monthly mean relative humidity.	Average monthly maximum temperature.	Average monthly minimum temperature.	Precipitation.		
					Rain in inches.	No. of rainy days.	Hours of sunshine.
May	70.5	79.3	79.5	61.9	4.35	9	282 $\frac{1}{2}$
June	81.6	75.7	89.7	73.1	3.20	6	330 $\frac{1}{2}$
July	81.2	78.8	88.7	73.1	3.47	11	281 $\frac{1}{2}$
August	77.8	82.3	85.3	69.5	5.83	8	284
September	70.3	89.4	78.9	66.2	6.74	15	185 $\frac{1}{2}$
October	63.2	83.5	70.6	53.6	3.90	5	209
November	58.3	79.3	68.1	48.2	0.01	1	194 $\frac{1}{2}$
Sums	502.9	568.3	560.8	445.6	27.50	.....	1,773 $\frac{1}{2}$
Averages	71.8	81.2	80.1	63.7	3.93	.....	257.7

J. M. WHITE,
Meteorologist.

JANUARY 12, 1891.

ANALYTICAL DATA.

The analytical data of the culture work in Mississippi are given below. Under the head "description of parent seed head" are given the data describing the parent seed heads recorded in the pedigree books of the Department.

Variety.	Description of parent seed head.	Date.	No. of analysis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Red Liberian	137, Brix 19, Oct. 21	Sept. 29	1	10.5	1.5	5.78
Do.	do	Sept. 29	2	13.0	4.9	5.74
Do.	do	Sept. 29	3	8.5	.0	7.45
Do.	do	Sept. 29	4	12.5	4.0	5.00
Do.	do	Sept. 29	5	12.5	4.0	6.37
Do.	do	Sept. 29	6	11.0	3.9	5.55
Do.	do	Sept. 29	7	12.0	3.8	5.98
Do.	do	Sept. 29	8	11.5	2.9	6.28
Do.	do	Sept. 29	9	9.5	1.0	6.06
Do.	do	Sept. 29	10	13.0	4.3	6.45
Means .....	.....	.....	.....	11.4	3.0	6.07

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Red Liberian	138, Brix 18, Oct. 21	Sept. 29	11	11.5	5.3	4.54
Do.	do	Sept. 29	12	10.5	2.6	5.15
Do.	do	Sept. 29	13	14.0	7.3	4.08
Do.	do	Sept. 29	14	15.5	9.2	4.23
Do.	do	Sept. 29	15	14.5	8.1	3.98
Do.	do	Oct. 1	16	11.0	1.4	5.68
Do.	do	Oct. 1	17	7.5	.0	4.27
Do.	do	Oct. 1	18	12.0	4.1	4.95
Do.	do	Oct. 1	19	12.0	3.8	5.00
Do.	do	Oct. 1	20	13.0	6.1	4.15
Means .....	.....	.....	.....	12.2	4.8	4.60
Red Liberian	125, 13254, Sucrose 15.04, Oct. 11	Oct. 1	21	12.0	4.8	4.54
Do.	do	Oct. 1	22	13.0	4.8	4.88
Do.	do	Oct. 1	23	12.0	3.1	5.23
Do.	do	Oct. 1	24	7.5	.0	4.45
Do.	do	Oct. 1	25	13.0	4.6	4.65
Do.	do	Oct. 1	26	12.0	3.6	5.15
Do.	do	Oct. 1	27	11.0	2.2	5.07
Do.	do	Oct. 1	28	14.5	6.7	4.32
Do.	do	Oct. 1	29	14.0	5.9	4.38
Do.	do	Oct. 1	30	13.0	6.5	4.76
Means .....	.....	.....	.....	12.2	4.2	4.74
Red Liberian	135, Brix 18	Oct. 1	31	13.0	6.0	4.44
Do.	do	Oct. 1	32	13.0	5.9	4.23
Do.	do	Oct. 1	33	10.5	3.3	4.83
Do.	do	Oct. 1	34	10.0	2.0	5.28
Do.	do	Oct. 1	35	12.0	4.3	5.15
Do.	do	Oct. 1	36	11.5	4.6	4.76
Do.	do	Oct. 1	37	10.5	2.7	5.02
Do.	do	Oct. 1	38	13.0	4.9	4.92
Do.	do	Oct. 1	39	12.0	3.9	4.76
Do.	do	Oct. 1	40	12.5	5.3	4.76
Means .....	.....	.....	.....	11.8	4.3	4.82
Red Liberian	125, 13258, Sucrose 14.81	Oct. 2	41	14.0	6.3	4.63
Do.	do	Oct. 2	42	14.0	6.2	4.80
Do.	do	Oct. 2	43	16.0	8.9	4.13
Do.	do	Oct. 2	44	12.0	1.8	6.25
Do.	do	Oct. 2	45	11.5	3.5	5.13
Do.	do	Oct. 2	46	15.0	5.9	5.02
Do.	do	Oct. 2	47	14.0	5.7	4.76
Do.	do	Oct. 2	48	15.5	7.9	4.85
Do.	do	Oct. 2	49	13.5	5.5	4.92
Do.	do	Oct. 2	50	15.0	8.5	3.09
Means .....	.....	.....	.....	14.1	6.0	4.76
Undendebule	297, Brix 18	Oct. 2	51	13.0	7.8	1.60
Do.	do	Oct. 2	52	11.0	4.6	2.64
Do.	do	Oct. 2	53	15.0	9.1	1.69
Do.	do	Oct. 2	54	16.5	10.7	.92
Do.	do	Oct. 2	55	10.5	4.7	1.78
Do.	do	Oct. 2	56	15.0	9.8	1.25
Do.	do	Oct. 2	57	6.5	1.6	1.69
Do.	do	Oct. 2	58	10.0	4.3	1.67
Do.	do	Oct. 2	59	11.5	6.0	2.00
Do.	do	Oct. 2	60	11.0	5.0	1.85
Means .....	.....	.....	.....	12.0	6.4	1.71
Undendebule	31, Brix 21, Oct. 2	Oct. 2	61	17.5	12.0	1.70
Do.	do	Oct. 2	62	16.5	11.6	1.50
Do.	do	Oct. 2	63	17.5	13.0	1.43
Do.	do	Oct. 2	64	17.5	12.5	1.41
Do.	do	Oct. 2	65	17.5	12.8	1.23
Do.	do	Oct. 3	66	20.0	14.2	1.16
Do.	do	Oct. 3	67	20.5	14.7	1.08
Do.	do	Oct. 3	68	17.5	12.8	1.66
Do.	do	Oct. 3	69	20.5	14.5	1.00
Do.	do	Oct. 3	70	18.0	13.0	1.30
Means .....	.....	.....	.....	18.3	13.1	1.35

Variety.	Description of parent seed head.	Date.	No. of analysis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				Per cent.	Per cent.	Per cent.
Undendebule	31, Brix 20, Oct. 4	Oct. 3	71	8.0	2.2	2.56
Do.	do	Oct. 3	72	14.0	9.4	1.45
Do.	do	Oct. 3	73	13.5	8.3	1.76
Do.	do	Oct. 3	74	13.5	7.5	2.21
Do.	do	Oct. 3	75	12.5	6.8	2.30
Do.	do	Oct. 3	76	11.0	4.8	2.27
Do.	do	Oct. 3	77	12.0	7.1	1.44
Do.	do	Oct. 3	78	10.5	5.7	2.24
Do.	do	Oct. 3	79	13.5	8.1	1.63
Do.	do	Oct. 3	80	12.5	6.8	2.39
Means .....	.....	.....	.....	12.1	6.7	2.03
Undendebule	254, 11749, sucrose 15.53	Oct. 3	81	18.0	13.3	.97
Do.	do	Oct. 3	82	20.0	15.2	.54
Do.	do	Oct. 3	83	12.0	6.4	1.90
Do.	do	Oct. 3	84	17.0	12.2	1.26
Do.	do	Oct. 3	85	8.5	3.7	2.05
Do.	do	Oct. 3	86	14.5	9.4	1.05
Do.	do	Oct. 3	87	17.0	12.3	1.07
Do.	do	Oct. 3	88	19.0	13.1	.73
Do.	do	Oct. 3	89	14.5	9.4	1.47
Do.	do	Oct. 3	90	15.0	9.5	1.78
Means .....	.....	.....	.....	15.6	10.5	1.28
Rio Blanco	107, Brix 21, Oct. 7	Oct. 4	91	15.5	9.4	4.04
Do.	do	Oct. 4	92	12.5	8.1	3.55
Do.	do	Oct. 4	93	16.0	10.0	3.98
Do.	do	Oct. 4	94	13.0	8.7	3.34
Do.	do	Oct. 4	95	13.5	7.5	3.93
Do.	do	Oct. 4	96	12.5	6.5	3.69
Do.	do	Oct. 4	97	9.0	3.7	3.93
Do.	do	Oct. 4	98	13.0	7.3	4.04
Do.	do	Oct. 4	99	14.0	8.8	3.57
Do.	do	Oct. 4	100	13.5	7.9	4.21
Means .....	.....	.....	.....	13.3	7.8	3.83
Rio Blanco	107, Brix 20, Oct. 9	Oct. 4	101	14.5	9.4	2.92
Do.	do	Oct. 4	102	16.5	11.4	4.00
Do.	do	Oct. 4	103	13.5	8.9	2.83
Do.	do	Oct. 4	104	16.5	11.7	2.90
Do.	do	Oct. 4	105	15.5	10.0	4.11
Do.	do	Oct. 4	106	14.5	9.8	3.36
Do.	do	Oct. 4	107	15.0	10.4	3.12
Do.	do	Oct. 4	108	16.5	11.8	3.18
Do.	do	Oct. 4	109	13.0	7.5	3.39
Do.	do	Oct. 4	110	16.5	11.5	3.71
Means .....	.....	.....	.....	15.2	9.2	3.45
India and Orange ..	289, Brix 21, Oct. 11	Oct. 4	111	15.5	10.7	2.29
Do.	do	Oct. 4	112	14.5	9.5	2.95
Do.	do	Oct. 4	113	15.5	10.5	2.84
Do.	do	Oct. 4	114	15.5	10.8	3.24
Do.	do	Oct. 4	115	16.5	12.1	2.34
Do.	do	Oct. 6	116	13.0	6.8	2.34
Do.	do	Oct. 6	117	13.0	7.6	2.65
Do.	do	Oct. 6	118	15.0	10.1	2.97
Do.	do	Oct. 6	119	12.5	7.1	3.16
Do.	do	Oct. 6	120	15.5	11.1	3.18
Means .....	.....	.....	.....	14.7	9.6	2.90
India and Orange ..	289, 14175, sucrose 16.42, Oct. 26	Oct. 6	121	18.0	12.4	3.21
Do.	do	Oct. 6	122	14.5	9.0	2.42
Do.	do	Oct. 6	123	15.0	10.4	3.04
Do.	do	Oct. 6	124	10.0	4.0	3.16
Do.	do	Oct. 6	125	18.0	13.0	1.73
Do.	do	Oct. 6	126	18.5	11.5	2.47
Do.	do	Oct. 6	127	17.5	10.9	3.33
Do.	do	Oct. 6	128	11.0	4.2	3.41
Do.	do	Oct. 6	129	18.0	12.2	3.56
Do.	do	Oct. 6	130	18.0	12.9	1.61
Means .....	.....	.....	.....	15.9	10.1	2.79

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solids.	Sucrose	Glucose.
				Per cent.	Per cent	Per cent.
Pettus		Oct. 6	131	Worthless.		
Do.		Oct. 6	132			
Do.		Oct. 6	133			
Do.		Oct. 6	134			
Do.		Oct. 6	135			
Do.		Oct. 6	136			
Do.		Oct. 6	137			
Do.		Oct. 6	138			
Do.		Oct. 6	139			
Do.		Oct. 6	140			
Var. of Honduras ..	112, 12677, sucrose 16.72, Oct. 8	Oct. 7	141	12.5	7.6	2.18
Do.	do	Oct. 7	142	11.0	6.3	1.44
Do.	do	Oct. 7	143	15.0	10.9	1.20
Do.	do	Oct. 7	144	10.5	4.8	3.46
Do.	do	Oct. 7	145	10.0	3.7	2.76
Do.	do	Oct. 7	146	11.0	4.7	3.80
Do.	do	Oct. 7	147	11.0	5.0	2.70
Do.	do	Oct. 7	148	14.0	9.7	1.14
Do.	do	Oct. 7	149	13.0	8.1	2.00
Do.	do	Oct. 7	150	9.5	3.2	3.58
Means				11.8	6.4	2.43
Bicolor	259, 13799, sucrose 13.25, Oct. 23	Oct. 7	151	15.0	9.2	1.26
Do.	do	Oct. 7	152	13.0	7.7	1.10
Do.	do	Oct. 7	153	12.5	6.5	1.13
Do.	do	Oct. 7	154	17.5	12.2	.97
Do.	do	Oct. 7	155	12.0	7.2	1.33
Do.	do	Oct. 7	156	17.0	12.2	.83
Do.	do	Oct. 7	157	Worthless.		
Do.	do	Oct. 7	158		9.0	.75
Do.	do	Oct. 7	159		6.5	1.44
Do.	do	Oct. 7	160		5.2	.91
Means				14.3	8.4	1.08
Bicolor	231, Brix 19, Oct. 5	Oct. 7	161	15.5	11.2	1.13
Do.	do	Oct. 7	162	11.0	4.2	1.83
Do.	do	Oct. 7	163	12.0	7.6	1.53
Do.	do	Oct. 7	164	10.5	5.4	2.21
Do.	do	Oct. 7	165	10.5	5.4	1.81
Do.	do	Oct. 8	166	10.0	3.9	1.73
Do.	do	Oct. 8	167	8.5	2.4	2.30
Do.	do	Oct. 8	168	8.0	2.2	2.36
Do.	do	Oct. 8	169	9.0	3.5	2.12
Do.	do	Oct. 8	170	12.5	7.8	2.46
Means				10.8	6.4	1.95
Ubelhana	255, Brix 18, Oct. 26	Oct. 8	171	14.0	8.0	3.16
Do.	do	Oct. 8	172	14.0	7.2	3.92
Do.	do	Oct. 8	173	14.0	7.6	3.95
Do.	do	Oct. 8	174	13.0	5.7	4.06
Do.	do	Oct. 8	175	15.5	10.0	2.63
Do.	do	Oct. 8	176	15.0	8.6	2.78
Do.	do	Oct. 8	177	12.0	6.1	3.73
Do.	do	Oct. 8	178	13.0	4.8	3.50
Do.	do	Oct. 8	179	12.0	5.8	3.73
Do.	do	Oct. 8	180	16.0	9.0	3.39
Means				13.9	7.3	3.49
Amber and Orange.	293, Brix 21, Oct. 9	Oct. 8	181	16.0	8.0	2.59
Do.	do	Oct. 8	182	14.5	8.3	2.24
Do.	do	Oct. 8	183	17.0	13.1	1.08
Do.	do	Oct. 8	184	16.0	7.3	1.77
Do.	do	Oct. 8	185	16.5	12.2	1.31
Do.	do	Oct. 8	186	17.0	12.9	1.60
Do.	do	Oct. 8	187	17.5	11.6	1.06
Do.	do	Oct. 8	188	14.0	8.5	2.34
Do.	do	Oct. 8	189	18.0	12.3	1.03
Do.	do	Oct. 8	190	16.0	11.5	1.87
Means				16.3	10.6	1.69

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				Per cent.	Per cent.	Per cent.
Amber and Orange.	293, Brix 22.5, Oct. 10	Oct. 9	191	19.0	12.9	1.00
Do	do	Oct. 9	192	19.0	15.0	1.04
Do	do	Oct. 9	193	18.0	12.3	.79
Do	do	Oct. 9	194	19.0	14.0	.76
Do	do	Oct. 9	195	17.5	12.6	1.03
Do	do	Oct. 9	196	19.0	13.6	.99
Do	do	Oct. 9	197	18.0	13.6	.98
Do	do	Oct. 9	198	18.0	12.6	.73
Do	do	Oct. 9	199	19.5	13.4	.88
Do	do	Oct. 9	200	18.0	13.0	.69
Means .....	.....			18.5	13.3	.89
Amber and Orange.	293, Brix 21.5, Oct. 12	Oct. 9	201	18.5	11.7	.95
Do	do	Oct. 9	202	19.5	12.3	.86
Do	do	Oct. 9	203	17.0	11.5	1.01
Do	do	Oct. 9	204	18.6	12.7	1.43
Do	do	Oct. 9	205	19.0	11.8	1.28
Do	do	Oct. 9	206	15.0	8.7	1.35
Do	do	Oct. 9	207	19.5	14.4	1.02
Do	do	Oct. 9	208	17.0	11.6	1.11
Do	do	Oct. 9	209	16.0	10.0	1.48
Do	do	Oct. 9	210	17.0	11.5	1.48
Means .....	.....			17.7	11.6	1.16
Link's Hybrid	162, Brix 19, Sept. 25	Oct. 9	211	14.0	9.9	1.49
Do	do	Oct. 9	212	14.5	11.3	.88
Do	do	Oct. 9	213	11.5	7.0	1.81
Do	do	Oct. 9	214	16.0	12.2	1.02
Do	do	Oct. 9	215	14.0	11.0	1.12
Do	do	Oct. 10	216	14.5	9.7	1.87
Do	do	Oct. 10	217	14.5	9.8	1.77
Do	do	Oct. 10	218	12.0	7.3	1.82
Do	do	Oct. 10	219	15.5	11.4	1.30
Do	do	Oct. 10	220	14.5	10.5	1.26
Means .....	.....			14.1	10.0	1.43
Link's Hybrid	162, Brix 19.5, Oct. 1	Oct. 10	221	15.0	9.5	2.96
Do	do	Oct. 10	222	16.0	10.5	2.53
Do	do	Oct. 10	223	14.0	8.7	2.44
Do	do	Oct. 10	224	16.5	10.8	3.44
Do	do	Oct. 10	225	16.5	12.1	1.59
Do	do	Oct. 10	226	17.0	11.3	3.00
Do	do	Oct. 10	227	10.0	3.9	4.00
Do	do	Oct. 10	228	16.0	12.6	.96
Do	do	Oct. 10	229	13.0	8.1	2.65
Do	do	Oct. 10	230	13.5	8.4	2.18
Means .....	.....			14.8	9.6	2.57
Link's Hybrid	154, Brix 21, Oct. 8	Oct. 10	231	16.0	11.3	1.92
Do	do	Oct. 10	232	17.0	12.1	1.27
Do	do	Oct. 10	233	17.0	12.7	1.00
Do	do	Oct. 10	234	16.5	12.2	1.10
Do	do	Oct. 10	235	15.0	10.5	1.91
Do	do	Oct. 10	236	18.0	10.7	1.02
Do	do	Oct. 10	237	15.5	11.0	1.62
Do	do	Oct. 10	238	18.0	13.3	1.30
Do	do	Oct. 10	239	18.0	13.3	1.02
Do	do	Oct. 10	240	13.5	8.9	2.31
Means .....	.....			16.5	11.6	1.45
Link's Hybrid	194, 11586, sucrose 16.01, glucose 0.53, Sept. 28.	Oct. 11	241	13.0	5.0	4.78
Do	do	Oct. 11	242	14.0	6.5	4.85
Do	do	Oct. 11	243	16.0	9.4	4.05
Do	do	Oct. 11	244	13.5	6.8	3.61
Do	do	Oct. 11	245	15.0	7.1	5.31
Do	do	Oct. 11	246	15.0	8.2	4.71
Do	do	Oct. 11	247	16.0	10.3	3.07
Do	do	Oct. 11	248	15.0	8.2	4.25
Do	do	Oct. 11	249	13.5	5.4	4.85
Do	do	Oct. 11	250	16.0	9.3	3.89
Means .....	.....			14.7	7.6	4.34

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Red Liberian	134, 13631, sucrose 13.52, Oct. 21	Oct. 11	251	13.0	5.0	1.32
Do	do	Oct. 11	252	13.5	5.8	2.70
Do	do	Oct. 11	253	15.0	10.1	2.00
Do	do	Oct. 11	254	15.0	8.2	2.15
Do	do	Oct. 11	255	16.0	11.0	1.37
Do	do	Oct. 11	256	14.5	9.0	1.58
Do	do	Oct. 11	257	13.0	8.3	1.63
Do	do	Oct. 11	258	16.0	9.1	2.30
Do	do	Oct. 11	259	13.0	7.5	2.04
Do	do	Oct. 11	260	15.0	10.5	1.70
Means .....	.....	.....	.....	14.4	8.5	1.88
Red Liberian	138, 13655, sucrose 13.97	Oct. 11	261	13.5	6.3	4.63
Do	do	Oct. 11	262	16.0	9.1	3.98
Do	do	Oct. 11	263	15.0	5.9	5.46
Do	do	Oct. 11	264	15.5	7.9	4.23
Do	do	Oct. 11	265	15.0	7.3	2.35
Do	do	Oct. 13	266	16.0	9.3	4.38
Do	do	Oct. 13	267	10.5	2.7	5.55
Do	do	Oct. 13	268	11.0	3.0	5.40
Do	do	Oct. 13	269	11.5	4.1	5.07
Do	do	Oct. 13	270	12.5	6.5	4.76
Means .....	.....	.....	.....	13.7	6.2	4.58
Red Liberian	146, Brix 19, Oct. 22	Oct. 13	271	12.5	6.6	3.61
Do	do	Oct. 13	272	12.5	5.0	4.92
Do	do	Oct. 13	273	13.0	5.0	5.00
Do	do	Oct. 13	274	17.0	9.2	4.42
Do	do	Oct. 13	275	18.0	12.0	2.67
Do	do	Oct. 13	276	11.5	3.8	5.20
Do	do	Oct. 13	277	11.5	4.1	4.80
Do	do	Oct. 13	278	10.0	3.3	5.00
Do	do	Oct. 13	279	13.0	6.2	5.05
Do	do	Oct. 13	280	15.0	6.3	4.83
Means .....	.....	.....	.....	13.4	6.2	4.55
Red Liberian	146, Brix 18.5	Oct. 13	281	16.5	9.4	3.77
Do	do	Oct. 13	282	13.0	6.4	5.49
Do	do	Oct. 13	283	16.5	7.9	4.00
Do	do	Oct. 13	284	12.5	5.5	4.63
Do	do	Oct. 13	285	13.5	7.0	4.36
Do	do	Oct. 13	286	14.0	6.1	4.83
Do	do	Oct. 13	287	13.5	4.9	5.68
Do	do	Oct. 13	288	14.0	6.4	5.31
Do	do	Oct. 13	289	15.5	8.5	3.85
Do	do	Oct. 13	290	15.0	7.3	4.13
Means .....	.....	.....	.....	14.4	6.9	4.61
Red Liberian	127, Brix 19.5	Oct. 14	291	12.5	4.6	3.93
Do	do	Oct. 14	292	12.5	3.3	6.25
Do	do	Oct. 14	293	13.5	4.4	4.52
Do	do	Oct. 14	294	12.5	3.8	3.70
Do	do	Oct. 14	295	13.0	4.4	3.45
Do	do	Oct. 14	296	13.0	5.2	3.85
Do	do	Oct. 14	297	12.5	3.4	3.50
Do	do	Oct. 14	298	13.5	5.9	3.53
Do	do	Oct. 14	299	12.5	3.6	3.57
Do	do	Oct. 14	300	15.0	5.9	5.84
Means .....	.....	.....	.....	13.1	4.5	4.21
Red Liberian	127, Brix 19.5	Oct. 14	301	14.0	5.9	5.46
Do	do	Oct. 14	302	14.5	6.1	5.34
Do	do	Oct. 14	303	15.5	8.0	4.54
Do	do	Oct. 14	304	17.0	11.0	3.57
Do	do	Oct. 14	305	17.5	10.6	4.25
Do	do	Oct. 14	306	16.0	8.9	4.46
Do	do	Oct. 14	307	17.5	10.8	4.35
Do	do	Oct. 14	308	17.0	9.1	4.09
Do	do	Oct. 14	309	18.0	9.1	3.53
Do	do	Oct. 14	310	16.0	9.7	3.59
Means .....	.....	.....	.....	16.3	8.9	4.32

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Undendebule	31, Brix 20, Oct. 4	Oct. 14	311	12.0	6.4	2.07
Do.	do	Oct. 14	312	16.0	10.5	1.23
Do.	do	Oct. 14	313	18.0	10.0	2.08
Do.	do	Oct. 14	314	17.0	12.1	1.32
Do.	do	Oct. 14	315	14.0	8.3	2.59
Do.	do	Oct. 15	316	15.5	9.1	2.78
Do.	do	Oct. 15	317	15.0	9.5	2.25
Do.	do	Oct. 15	318	16.0	10.7	2.16
Do.	do	Oct. 15	319	15.0	9.8	2.84
Do.	do	Oct. 15	320	14.0	7.6	2.12
Means .....	.....	.....	.....	15.3	9.4	2.14
Rio Blanco	107, Brix 21, Oct. 7	Oct. 15	321	17.5	11.9	2.78
Do.	do	Oct. 15	322	16.5	10.3	2.36
Do.	do	Oct. 15	323	18.0	13.1	2.38
Do.	do	Oct. 15	324	18.0	11.4	2.59
Do.	do	Oct. 15	325	18.0	12.7	2.06
Do.	do	Oct. 15	326	16.5	11.5	2.35
Do.	do	Oct. 15	327	16.0	10.8	2.53
Do.	do	Oct. 15	328	17.0	10.1	3.58
Do.	do	Oct. 15	329	17.0	11.3	2.73
Do.	do	Oct. 15	330	18.0	7.7	2.49
Means .....	.....	.....	.....	17.3	10.1	2.59
Var. of Honduras ..	112, Brix 19, Sept. 24	Oct. 15	331	17.5	12.5	.75
Do.	do	Oct. 15	332	16.5	11.7	.90
Do.	do	Oct. 15	333	16.5	11.7	.84
Do.	do	Oct. 15	334	16.5	11.9	.92
Do.	do	Oct. 15	335	18.0	13.2	.66
Do.	do	Oct. 15	336	17.5	12.2	.91
Do.	do	Oct. 15	337	16.0	10.8	.92
Do.	do	Oct. 15	338	16.5	11.7	.82
Do.	do	Oct. 15	339	17.5	13.0	.98
Do.	do	Oct. 15	340	16.5	11.9	.77
Means .....	.....	.....	.....	16.9	12.1	.85
India and Orange ..	289, Brix 19, Oct. 26	Oct. 16	341	13.5	7.7	2.42
Do.	do	Oct. 16	342	17.5	12.7	1.08
Do.	do	Oct. 16	343	17.5	11.8	1.24
Do.	do	Oct. 16	344	15.0	10.0	1.96
Do.	do	Oct. 16	345	16.5	10.7	1.96
Do.	do	Oct. 16	346	14.5	8.8	2.47
Do.	do	Oct. 16	347	17.5	12.5	.71
Do.	do	Oct. 16	348	17.5	13.2	.59
Do.	do	Oct. 16	349	18.0	12.1	1.34
Do.	do	Oct. 16	350	18.5	13.3	.87
Means .....	.....	.....	.....	16.6	11.3	1.46
Var. of Honduras ..	112, Brix 21, Oct. 8	Oct. 16	351	16.5	11.6	.94
Do.	do	Oct. 16	352	16.0	11.5	1.30
Do.	do	Oct. 16	353	16.5	10.0	1.18
Do.	do	Oct. 16	354	17.5	11.4	1.13
Do.	do	Oct. 16	355	14.5	5.9	1.39
Do.	do	Oct. 16	356	15.0	10.7	1.05
Do.	do	Oct. 16	357	15.5	11.2	1.40
Do.	do	Oct. 16	358	17.0	12.5	.97
Do.	do	Oct. 16	359	16.0	10.9	.87
Do.	do	Oct. 16	360	17.5	12.4	1.04
Means .....	.....	.....	.....	16.2	10.8	1.03
Bicolor	259, Brix 18, Oct. 4	Oct. 16	361	17.5	11.8	.76
Do.	do	Oct. 16	362	18.0	12.3	.81
Do.	do	Oct. 16	363	17.0	11.4	.95
Do.	do	Oct. 16	364	17.5	12.7	.82
Do.	do	Oct. 16	365	17.0	12.3	.75
Do.	do	Oct. 17	366	17.5	12.7	.64
Do.	do	Oct. 17	367	18.0	13.2	.74
Do.	do	Oct. 17	368	18.0	13.4	.62
Do.	do	Oct. 17	369	17.5	12.6	.70
Do.	do	Oct. 17	370	17.5	12.5	.59
Means .....	.....	.....	.....	17.6	12.5	.74

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solid.	Sucrose.	Glucose.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Amber and Orange	293, 13927, cane sugar 15.85, Oct. 24.	Oct. 17	371	20.0	15.1	.26
Do.	do	Oct. 17	372	18.5	13.6	.81
Do.	do	Oct. 17	373	19.0	14.2	.62
Do.	do	Oct. 17	374	18.5	11.9	1.04
Do.	do	Oct. 17	375	18.0	13.5	1.50
Do.	do	Oct. 17	376	18.5	13.5	.83
Do.	do	Oct. 17	377	17.5	11.9	1.36
Do.	do	Oct. 17	378	19.5	14.1	.72
Do.	do	Oct. 17	379	18.5	13.7	.80
Do.	do	Oct. 17	380	19.0	12.9	.71
Means				18.7	13.4	.88
Link's Hybrid	167, Brix 19, Oct. 23	Oct. 17	381	17.0	11.4	1.15
Do.	do	Oct. 17	382	16.5	12.1	.96
Do.	do	Oct. 17	383	16.5	11.8	1.33
Do.	do	Oct. 17	384	18.0	13.7	1.00
Do.	do	Oct. 17	385	16.0	11.3	1.47
Do.	do	Oct. 17	386	14.0	9.0	2.37
Do.	do	Oct. 17	387	16.0	11.5	1.56
Do.	do	Oct. 17	388	13.5	8.8	2.08
Do.	do	Oct. 17	389	15.0	10.5	1.61
Do.	do	Oct. 17	390	17.0	12.9	.71
Means				16.0	11.3	1.42
Link's Hybrid	162, Brix 20, Sept. 25	Oct. 18	391	17.5	12.7	1.72
Do.	do	Oct. 18	392	16.5	11.3	1.67
Do.	do	Oct. 18	393	16.5	11.4	1.57
Do.	do	Oct. 18	394	17.5	13.2	1.04
Do.	do	Oct. 18	395	16.5	12.1	1.54
Do.	do	Oct. 18	396	13.5	8.5	1.47
Do.	do	Oct. 18	397	16.0	11.1	1.64
Do.	do	Oct. 18	398	17.0	12.8	1.07
Do.	do	Oct. 18	399	18.0	13.1	.79
Do.	do	Oct. 18	400	18.5	14.3	.58
Means				16.8	12.1	1.31
Link's Hybrid	162, Brix 21, Oct. 1	Oct. 18	401	17.0	11.7	1.57
Do.	do	Oct. 18	402	16.5	11.7	1.60
Do.	do	Oct. 18	403	19.0	14.4	.81
Do.	do	Oct. 18	404	15.0	9.5	1.85
Do.	do	Oct. 18	405	16.5	12.0	1.23
Do.	do	Oct. 18	406	17.5	13.1	.97
Do.	do	Oct. 18	407	17.0	12.6	1.37
Do.	do	Oct. 18	408	19.0	14.6	.58
Do.	do	Oct. 18	409	18.0	13.7	.55
Do.	do	Oct. 18	410	15.0	10.0	1.47
Means				17.1	12.3	1.20
Link's Hybrid	165, 11491, sucrose 16.69	Oct. 18	411	18.5	13.8	1.17
Do.	do	Oct. 18	412	19.0	15.0	.68
Do.	do	Oct. 18	413	19.0	12.6	1.05
Do.	do	Oct. 18	414	18.0	13.4	1.46
Do.	do	Oct. 18	415	18.0	14.3	1.05
Do.	do	Oct. 20	416	18.0	13.8	.80
Do.	do	Oct. 20	417	18.5	13.6	.88
Do.	do	Oct. 20	418	19.0	14.1	1.03
Do.	do	Oct. 20	419	17.5	12.2	2.08
Do.	do	Oct. 20	420	18.0	12.8	1.30
Means				18.4	13.6	1.15
Link's Hybrid	194, 13897, sucrose 15.66, Oct. 24	Oct. 20	421	15.0	8.6	2.19
Do.	do	Oct. 20	422	15.5	9.5	2.20
Do.	do	Oct. 20	423	16.0	10.6	1.84
Do.	do	Oct. 20	424	19.5	14.0	1.43
Do.	do	Oct. 20	425	16.5	11.5	1.32
Do.	do	Oct. 20	426	18.5	13.5	.92
Do.	do	Oct. 20	427	14.5	8.8	2.07
Do.	do	Oct. 20	428	18.5	14.5	1.00
Do.	do	Oct. 20	429	18.5	14.1	1.22
Do.	do	Oct. 20	430	17.0	11.3	1.05
Means				17.0	11.6	1.52

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Link's Hybrid.....	194, 11558, sucrose 16.21, Sept. 28...	Oct. 20	431	15.0	9.8	1.56
Do.....	do	Oct. 20	432	15.5	9.8	1.49
Do.....	do	Oct. 20	433	16.5	11.3	1.71
Do.....	do	Oct. 20	434	14.5	8.7	2.21
Do.....	do	Oct. 20	435	14.0	8.6	1.78
Do.....	do	Oct. 20	436	14.0	8.3	1.71
Do.....	do	Oct. 20	437	15.5	10.3	1.56
Do.....	do	Oct. 20	438	14.0	8.6	1.68
Do.....	do	Oct. 20	439	14.5	9.1	2.41
Do.....	do	Oct. 20	440	16.0	11.1	1.55
Means.....				15.0	9.6	1.76
Link's Hybrid.....	162, 13379, Brix 20, Sept. 25.....	Oct. 21	441	15.0	10.0	1.69
Do.....	do	Oct. 21	442	15.0	9.9	2.25
Do.....	do	Oct. 21	443	14.5	8.0	3.20
Do.....	do	Oct. 21	444	14.5	8.7	2.97
Do.....	do	Oct. 21	445	15.0	9.1	2.48
Do.....	do	Oct. 21	446	15.0	9.0	2.45
Do.....	do	Oct. 21	447	16.0	10.7	2.00
Do.....	do	Oct. 21	448	15.0	9.4	2.25
Do.....	do	Oct. 21	449	15.5	10.1	2.23
Do.....	do	Oct. 21	450	15.5	10.5	2.71
Means.....				15.1	9.5	2.42
Link's Hybrid.....	194, 11585, sucrose 15.80, Sept. 28 ..	Oct. 21	451	16.5	11.6	2.78
Do.....	do	Oct. 21	452	17.5	11.8	2.63
Do.....	do	Oct. 21	453	17.0	11.7	2.50
Do.....	do	Oct. 21	454	16.5	10.3	2.74
Do.....	do	Oct. 21	455	17.0	11.1	2.61
Do.....	do	Oct. 21	456	18.0	12.6	2.24
Do.....	do	Oct. 21	457	18.0	12.6	1.98
Do.....	do	Oct. 21	458	16.5	10.6	2.31
Do.....	do	Oct. 21	459	17.5	12.7	2.02
Do.....	do	Oct. 21	460	16.5	11.6	2.24
Means.....				17.1	11.7	2.41
Link's Hybrid.....	164, Brix 19.5, Sept. 28	Oct. 21	461	16.0	10.6	1.95
Do.....	do	Oct. 21	462	15.5	10.0	2.19
Do.....	do	Oct. 21	463	15.0	9.6	2.36
Do.....	do	Oct. 21	464	14.0	8.5	2.22
Do.....	do	Oct. 21	465	14.0	8.5	2.68
Means.....				14.9	9.4	2.28
Amber and Orange.	293, 12142, sucrose 17.99, Oct. 3	Oct. 25	466	19.0	14.3	1.21
Do.....	do	Oct. 25	467	18.5	14.2	1.59
Do.....	do	Oct. 25	468	18.0	13.4	2.73
Do.....	do	Oct. 25	469	17.5	13.5	1.74
Do.....	do	Oct. 25	470	16.5	11.9	2.15
Means.....				17.9	13.5	1.89
Amber and Orange.	293, 13389, cane sugar 17.70, Oct. 12.	Oct. 25	471	18.0	13.6	1.83
Do.....	do	Oct. 25	472	17.0	12.9	2.01
Do.....	do	Oct. 25	473	17.5	12.3	2.62
Do.....	do	Oct. 25	474	19.0	14.5	1.60
Do.....	do	Oct. 25	475	19.5	15.5	1.33
Means.....				18.2	13.8	1.88
Amber and Orange.	293, 12132, sucrose 17.99, Oct. 31	Oct. 25	476	18.0	13.7	.81
Do.....	do	Oct. 25	477	16.5	12.0	1.87
Do.....	do	Oct. 25	478	18.0	13.9	.71
Do.....	do	Oct. 25	479	16.5	12.2	1.04
Do.....	do	Oct. 25	480	14.5	10.7	1.40
Means.....				16.7	12.5	1.17
Amber and Orange	293, 13398, cane sugar 17.62, Oct. 12.	Oct. 25	481	17.0	13.5	1.00
Do.....	do	Oct. 25	482	18.5	14.4	1.24
Do.....	do	Oct. 25	483	18.0	12.6	1.41
Do.....	do	Oct. 25	484	16.0	12.3	1.55
Do.....	do	Oct. 25	485	16.5	12.3	1.64
Means.....				17.2	13.0	1.37

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Bicolor	51, Brix 19, Oct. 4	Oct. 25	486	12.5	8.5	1.39
Do.	do	Oct. 25	487	13.5	9.2	1.10
Do.	do	Oct. 25	488	15.5	11.1	1.69
Do.	do	Oct. 25	489	13.5	9.4	1.59
Do.	do	Oct. 25	490	14.5	10.0	1.82
Means .....	.....			13.9	9.6	1.50
Var. of Honduras ..	112, Brix 19, Sept. 23	Oct. 27	491	9.5	2.5	4.76
Do.	do	Oct. 27	492	10.5	6.1	2.44
Do.	do	Oct. 27	493	10.0	5.2	2.97
Do.	do	Oct. 27	494	10.5	5.4	2.87
Do.	do	Oct. 27	495	16.5	12.5	1.06
Means .....	.....			11.4	6.3	2.82
Var. of Honduras ..	112, Brix 19, Oct. 8	Oct. 27	496	14.0	10.1	1.43
Do.	do	Oct. 27	497	12.5	7.4	1.54
Do.	do	Oct. 27	498	10.5	5.4	2.78
Do.	do	Oct. 27	499	9.0	2.0	4.25
Do.	do	Oct. 27	500	9.0	2.0	4.73
Means .....	.....			11.0	5.4	2.95
Var. of Honduras ..	112, Brix 20, Oct. 8	Oct. 27	501	11.5	6.6	2.57
Do.	do	Oct. 27	502	13.5	7.0	4.13
Do.	do	Oct. 27	503	14.0	10.1	.92
Do.	do	Oct. 27	504	13.5	8.8	2.63
Do.	do	Oct. 27	505	12.0	5.0	4.31
Means .....	.....			12.9	7.5	2.91
Var. of Honduras ..	112, 12687, sucrose 16.75, Oct. 8	Oct. 27	506	13.5	8.3	2.93
Do.	do	Oct. 27	507	10.0	5.9	1.79
Do.	do	Oct. 27	508	16.0	12.1	1.55
Do.	do	Oct. 27	509	16.5	12.1	1.47
Do.	do	Oct. 27	610	15.0	11.0	.90
Means .....	.....			14.2	9.9	1.73
India and Orange ..	289, 13214, sucrose 17.31, Oct. 10.	Oct. 27	511	14.5	10.1	2.52
Do.	do	Oct. 27	512	19.0	14.6	.95
Do.	do	Oct. 27	513	13.0	7.9	3.66
Do.	do	Oct. 27	514	16.5	12.2	2.02
Do.	do	Oct. 27	515	13.5	8.5	2.65
Means .....	.....			15.3	10.7	2.36
Undendebule	254, 12475, sucrose 17.86, glucose 0.46	Oct. 28	516	19.0	14.0	.65
Do.	do	Oct. 28	217	15.0	10.8	.92
Do.	do	Oct. 28	518	15.0	10.4	1.02
Do.	do	Oct. 28	519	15.5	11.1	1.14
Do.	do	Oct. 28	520	18.5	13.9	.59
Means .....	.....			16.6	12.1	.86
Undendebule	254, 13133, sucrose 18.24	Oct. 28	521	13.5	9.4	.98
Do.	do	Oct. 28	522	14.5	10.0	1.43
Do.	do	Oct. 28	523	18.0	13.7	1.62
Do.	do	Oct. 28	524	15.0	11.4	1.39
Do.	do	Oct. 28	525	19.0	14.6	.53
Means .....	.....			16.0	11.8	1.18
Undendebule	254, 13336, sucrose 17.37, glucose 0.91	Oct. 28	526	17.5	13.8	.53
Do.	do	Oct. 28	527	19.0	15.8	.46
Do.	do	Oct. 28	528	20.5	16.4	.50
Do.	do	Oct. 28	529	17.5	13.3	.85
Do.	do	Oct. 28	530	19.0	14.7	.50
Means .....	.....			18.7	14.8	.57
Undendebule	254, 13127, sucrose 17.72, glucose 0.89	Oct. 28	531	18.0	13.5	.49
Do.	do	Oct. 28	532	16.5	12.7	.73
Do.	do	Oct. 28	533	10.5	5.4	2.17
Do.	do	Oct. 28	534	8.5	4.1	2.24
Do.	do	Oct. 28	535	17.0	12.5	.97
Means .....	.....			14.1	9.6	1.32

Variety.	Description of parent seed head.	Date.	No. of analy- sis.	In the juice.		
				Solids.	Sucrose.	Glucose.
				<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Red Liberian	141, 13720, sucrose 14.73	Oct. 28	536	16.0	8.8	4.35
Do	do	Oct. 28	537	14.0	7.0	4.20
Do	do	Oct. 28	538	11.0	3.8	4.78
Do	do	Oct. 28	539	14.0	7.0	4.38
Do	do	Oct. 28	540	12.5	5.9	4.29
Means				13.5	6.3	4.40
Red Liberian	135, Brix 19	Oct. 29	541	12.5	4.7	5.81
Do	do	Oct. 29	542	12.5	7.0	3.85
Do	do	Oct. 29	542	11.0	4.3	4.71
Do	do	Oct. 29	544	12.5	6.4	4.17
Do	do	Oct. 29	545	12.5	3.7	6.02
Means				12.2	5.2	4.91
Red Liberian	138, Brix 18.5, Oct. 21	Oct. 29	546	13.5	5.3	5.81
Do	do	Oct. 29	547	12.5	4.8	4.06
Do	do	Oct. 29	548	13.5	5.9	5.26
Do	do	Oct. 29	549	14.5	6.1	4.50
Do	do	Oct. 29	550	13.5	6.5	4.35
Means				13.5	5.7	5.00
Red Liberian	128, 13300, cane sugar 14.84	Oct. 29	551	16.0	8.8	4.58
Do	do	Oct. 29	552	11.0	2.0	6.02
Do	do	Oct. 29	553	16.0	8.6	4.85
Do	do	Oct. 29	554	13.5	5.7	6.25
Do	do	Oct. 29	555	14.5	6.2	6.25
Means				14.2	6.3	5.59
Red Liberian	130, 13647, sucrose 14.09	Oct. 29	556	13.5	3.4	6.67
Do	do	Oct. 29	557	12.5	2.0	7.24
Do	do	Oct. 29	558	11.0	2.7	6.59
Do	do	Oct. 29	559	12.5	2.0	7.69
Do	do	Oct. 29	560	16.0	7.6	5.81
Do	do	Oct. 29	561	12.5	3.3	5.71
Do	do	Oct. 29	562	14.5	6.7	5.37
Do	do	Oct. 29	563	13.5	5.5	6.32
Do	do	Oct. 29	564	13.5	6.4	5.61
Means				13.3	4.4	6.33
Red Liberian	137, Brix 19, Oct. 25	Oct. 31	565	16.0	7.3	5.55
Do	do	Oct. 31	566	16.0	9.6	3.85
Do	do	Oct. 31	567	16.0	7.9	4.76
Means				16.0	8.3	4.72
Red Liberian	138, Brix 18, Oct. 21	Oct. 31	568	15.0	6.8	4.35
Do	do	Oct. 31	569	12.5	5.4	4.35
Do	do	Oct. 31	570	12.5	6.1	4.42
Means				13.3	6.1	4.37
Red Liberian	125, 13254, sucrose 15.04, Oct. 11	Oct. 31	571	13.5	8.5	3.85
Do	do	Oct. 31	572	16.0	6.4	4.76
Do	do	Oct. 31	573	16.0	6.4	5.00
Means				15.2	7.1	4.54
Red Liberian	135, Brix 18	Oct. 31	574	16.0	6.9	4.17
Do	do	Oct. 31	575	12.5	3.9	4.20
Do	do	Oct. 31	576	13.5	4.8	6.25
Means				14.0	5.2	4.87
Red Liberian	125, 13258, sucrose 14.81	Oct. 31	577	13.5	4.8	5.55
Do	do	Oct. 31	578	13.5	3.0	5.55
Do	do	Oct. 31	579	16.0	7.1	5.55
Means				14.0	5.0	5.55

Variety.	Description of parent seed head.	Date.	No. of analysis.	In the juice.		
				Solids.	Sucrose.	Glucose.
Red Liberian	127, Brix 19.5	Oct. 31	580	<i>Per cent.</i> 17.0	<i>Per cent.</i> 13.7	<i>Per cent.</i> 2.56
Do.	do	Oct. 31	581	20.5	13.9	1.50
Do.	do	Oct. 31	582	20.5	15.3	.66
Do.	do	Oct. 31	583	20.5	13.9	.69
Do.	do	Oct. 31	584	20.5	15.5	.74
Do.	do	Oct. 31	585	18.0	15.5	.95
Means .....	.....			19.5	14.6	1.18
Amber and Orange.	293, 12142, sucrose, 17.99, Oct. 3	Oct. 31	586	19.5	15.0	1.01
Do.	do	Oct. 31	587	18.0	12.5	2.17
Do.	do	Oct. 31	588	18.0	13.8	1.72
Means .....	.....			18.5	13.8	1.97

CULTURE EXPERIMENTS AT FORT SCOTT, KANSAS.

Culture experiments were carried on at Fort Scott, Kansas, during the summer of 1890, under the direction of Prof. J. C. Hart. The seeds used were pedigreed seeds, produced at the Department station at Sterling during the previous year. The general result was as follows:

The Early Amber variety showed a mean of 17.3 per cent of total solids in the juice, 13.2 per cent sugar, and a purity of 76.3.

The cross of Amber and Orange showed a mean of 18.7 per cent of total solids, 14.1 of sugar, with a purity of 75.2.

Folger's Early showed 18.4 solids, 13.5 sugar, 73.4 purity.

A cross of Amber and Link's Hybrid showed 18.4 total solids, 13.0 sugar, with a purity of 70.9.

Undendebule showed 18.9 total solids, 13.5 sugar, 71.2 purity.

A cross of India and Orange showed 17.4 total solids, 12.6 sugar, 72.6 purity.

Link's Hybrid gave 18.6 total solids, 13.1 sugar, 70.5 purity.

The character of the other varieties tested will be sufficiently shown in the following tables, which give the analytical details. The description of the parent seed head refers to the numbers in the pedigree book of the Department.

Analyses of selected canes.

EARLY AMBER.

Parent stalk.				Growth of 1890.			
Plot number at Sterling.	Date.	Per cent solids.	Per cent sucrose.	Date.	Per cent solids.	Per cent sucrose.	Purity.
235.....	1889 Sept. 11	.....	13.49	1890			
				Aug. 25	17.5	13.65	78.0
				Aug. 25	17.0	13.20	77.6
				Aug. 25	18.0	14.1	78.3
				Aug. 25	17.8	14.1	79.2
				Aug. 25	16.2	12.1	74.7
				Aug. 25	18.3	14.0	76.5
				Aug. 25	16.5	11.7	71.0
				Aug. 14	16.0	12.9	80.6
				Aug. 16	18.5	13.85	75.0
				Aug. 16	17.7	.....	.....
				Aug. 20	16.8	12.8	76.2
				Aug. 21	17.1	12.75	74.6
					17.3	13.2	76.3
Means					18.5	14.1	80.6
Maxima					16.0	11.7	71.0
Minima							

CROSS OF AMBER AND ORANGE.

293.....	Sept. 28	.....	18.28	Sept. 6	18.6	15.0	80.6
				Sept. 6	19.0	14.05	74.0
				Sept. 9	18.7	14.05	75.1
				Sept. 13	17.5	13.1	74.3
				Sept. 13	18.5	13.4	72.4
				Sept. 13	18.3	13.35	73.0
				Sept. 13	19.2	14.8	77.1
				Sept. 13	18.5	13.25	71.6
				Sept. 18	18.2	14.0	76.8
				Sept. 18	17.8	13.87	78.0
				Sept. 19	18.8	13.95	74.2
				Sept. 19	19.6	16.1	83.4
				Sept. 20	18.8	13.8	73.4
				Sept. 20	18.1	13.9	76.8
				Sept. 20	18.6	14.75	79.3
				Sept. 20	19.0	14.8	77.9
293.....	Oct. 10	22.5	.....	Sept. 26	17.8	13.2	74.1
293.....	Oct. 2	21.5	.....	Oct. 14	21.44	15.6	72.7
				Oct. 24	18.9	12.3	65.1
Means					18.7	14.06	75.2
Maxima					21.44	16.1	83.4
Minima					17.5	12.3	65.1

FOLGER'S EARLY.

205.....	.....	19.0	.....	Sept. 9	18.0	12.8	71.0
				Sept. 9	17.7	12.15	68.6
				Sept. 9	18.7	12.85	68.7
				Sept. 9	18.5	12.8	69.2
				Sept. 9	19.3	13.8	71.5
				Aug. 25	17.5	12.75	72.8
				Sept. 1	18.5	13.75	74.3
				Sept. 1	19.1	14.5	76.0
				Sept. 1	19.1	15.0	78.5
				Sept. 3	19.0	14.7	77.3
				Sept. 3	18.5	14.7	80.0
				Sept. 6	19.4	15.6	80.4
				Sept. 26	15.8	10.7	67.7
					18.4	13.5	73.4
Means					19.4	15.6	80.4
Maxima					15.8	10.7	67.7
Minima							

Analyses of selected canes—Continued.

AMBER AND LINK'S HYBRID.

Parent isalk.				Growth of 1890.			
Plot number at Sterling.	Date.	Per cent solids.	Per cent sucrose.	Date.	Per cent solids.	Per cent sucrose.	Purity
172.....	1889 Oct. 24	.....	15.24	1890 Sept. 29	17.5	11.4	65.0
				Oct. 2	17.4	13.1	75.3
				Oct. 2	17.5	13.4	76.6
				Oct. 7	17.7	13.9	78.5
				Oct. 7	18.7	13.85	74.06
				Oct. 8	19.84	13.75	69.3
				Oct. 8	19.74	13.1	66.3
				Oct. 8	20.28	13.15	64.3
				Oct. 8	19.17	13.3	69.3
				Sept. 26	16.5	11.85	71.8
172.....	Oct. 2	19.5	16.19	Oct. 24	18.1	12.6	69.6
Means .....	.....	.....	.....	.....	18.4	13.0	70.9
Maxima .....	.....	.....	.....	.....	20.28	13.9	78.5
Minima .....	.....	.....	.....	.....	16.5	11.4	64.3

UNDENDEBULE.

254.....	Oct. 4	21.0	.....	Sept. 13	18.8	13.0	69.1
				Sept. 13	16.5	10.9	66.0
				Sept. 29	18.8	12.6	67.0
				Oct. 2	19.1	14.75	77.2
				Oct. 2	18.5	13.8	74.6
				Oct. 7	18.8	14.65	78.0
254.....	Oct. 10	20.0	.....	Oct. 26	21.53	14.50	67.3
Means .....	.....	.....	.....	.....	18.9	13.46	71.2
Maxima .....	.....	.....	.....	.....	21.53	14.75	78.0
Minima .....	.....	.....	.....	.....	16.5	10.9	66.0

INDIA AND ORANGE.

320.....	Oct. 25	.....	15.35	Sept. 29	18.1	12.9	71.2
				Oct. 2	17.3	13.3	76.8
				Oct. 2	17.3	13.3	76.8
				Oct. 7	15.3	11.95	78.1
				Oct. 7	15.6	11.0	70.5
				Oct. 11	20.34	14.5	70.6
				Oct. 11	19.44	14.4	74.1
				Oct. 11	20.54	15.0	73.0
318.....	Oct. 25	19.0	.....	Oct. 30	14.7	8.9	60.5
311.....	Oct. 25	18.0	.....	Oct. 30	15.1	11.1	73.5
Means .....	.....	.....	.....	.....	17.4	12.64	72.6
Maxima .....	.....	.....	.....	.....	20.54	14.5	78.1
Minima .....	.....	.....	.....	.....	14.7	8.9	60.5

LINK'S HYBRID.

194.....	Oct. 24	.....	15.38	Sept. 29	18.3	12.4	67.7
				Oct. 11	18.9	13.4	70.8
				Oct. 11	18.8	13.15	70.0
				Oct. 11	19.4	13.55	70.0
154.....	Oct. 8	.....	17.56	Oct. 14	17.8	12.3	70.0
116.....	Oct. 8	20.5	.....	Oct. 30	18.2	13.9	76.4
Means .....	.....	.....	.....	.....	18.6	13.12	70.5
Maxima .....	.....	.....	.....	.....	19.4	13.9	76.4
Minima .....	.....	.....	.....	.....	17.8	12.3	67.7

Analyses of selected canes—Continued.*

CHINESE.

Parent stalk.				Growth of 1890.			
Plot number at Sterling.	Date.	Per cent solids.	Per cent sucrose.	Date.	Per cent solids.	Per cent sucrose.	Purity.
39.....	1889. Oct. 24	.....	13.3	1890. Sept. 29	15.9	8.9	56.0
39.....	Oct. 25	17.0	.....	Oct. 28	16.7	10.0	59.9
Means ..	.....	.....	.....	.....	16.3	9.45	57.9

MANZANA.

12.....	Sept. 26	20.0	.....	Oct. 14	18.87	13.0	68.9
216.....	Oct. 10	19.0	.....	Oct. 26	16.35	11.4	69.7
Means ..	.....	.....	.....	.....	17.6	12.2	69.3

BLACK AFRICAN.

109.....	Sept. 18	.....	15.83	Sept. 26	16.1	11.3	70.0
.....	.....	.....	.....	Oct. 27	13.4	8.2	61.2
.....	.....	.....	.....	Oct. 28	17.97	12.6	70.0
Means ..	.....	.....	.....	.....	15.8	10.7	67.1
Maxima ..	.....	.....	.....	.....	17.97	12.6	70.0
Minima ..	.....	.....	.....	.....	13.4	8.2	61.2

HONDURAS.

120	Oct. 8	19.0		Oct. 12	16.7	11.5	68.9
-----------	--------	------	-------	---------	------	------	------

LINK'S HYBRID AND LIBERIAN.

176.....	Nov. 2	21.0		Oct. 24	18.0	12.7	70.6
----------	--------	------	-------	---------	------	------	------

RED LIBERIAN.

126..	Oct. 11	20.0	.....	Oct. 24	17.0	9.0	52.9
.....	.....	.....	.....	Oct. 30	15.5	8.1	52.3
Means ..	.....	.....	.....	.....	16.3	8.55	52.6

EARLY ORANGE.

239.....	Oct. 10	20.0		Oct. 27	16.8	11.2	66.6
----------	---------	------	-------	---------	------	------	------

SORGHUM BICOLOR.

396.....	Oct. 23	18.0		Oct. 30	15.33	11.3	73.7
----------	---------	------	-------	---------	-------	------	------

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 30.

EXPERIMENTS

WITH

SUGAR BEETS

IN

1890.

BY

HARVEY W. WILEY,

*Chemist of the U. S. Department of Agriculture and Director of the Department Sugar
Experiment Stations at Schuyler, Nebraska; Runnymede (Narcoossee P. O.),
Florida; and Sterling and Medicine Lodge, Kansas.*

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1891.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 30.

EXPERIMENTS

WITH

SUGAR BEETS

IN

1890.

BY

HARVEY W. WILEY,

*Chemist of the U. S. Department of Agriculture and Director of the Department Sugar
Experiment Stations at Schuyler, Nebraska; Rumynode (Narcoossee P. O.),
Florida; and Sterling and Medicine Lodge, Kansas.*

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1891.

PREFATORY NOTE.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., March 28, 1891.

SIR: I submit for your inspection and approval the manuscript of Bulletin No. 30 of the Chemical Division, containing a record of the experiments made by the Department in 1890 with sugar beets.

The work of the Department recorded in this bulletin consists chiefly of analyses of samples of beets grown in many different States. In addition to this work, a few culture experiments, on a small scale, were carried on under the supervision of the Department. A chemist from this Division was also stationed at the Grand Island Sugar Factory, in Nebraska, and data of the greatest value were secured at that place.

Special studies of the whole subject of the growth of the sugar beet and the manufacture of sugar therefrom were published in Bulletin No. 27. In Farmers' Bulletin No. 3 have been published full instructions for the culture of the sugar beet. The data contained in these two bulletins are supplemented by the facts recorded in the present one, which show further that beets of fine quality and well suited for manufacturing purposes can be grown in the United States.

So conclusive have been the results obtained as to fully justify the action of the Department in establishing a culture station at Schuyler, Nebraska, for the more exact study of the conditions of the most successful methods of growing sugar beets in this country.

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary of Agriculture.

TABLE OF CONTENTS.

	Page.
Experiments with sugar beets in 1890	7
Purchase and distribution of seeds	7
Experiments at factories	8
Financial returns to beet-growers	8
Analytical data from various States	10
Experiments with sugar beets in Wisconsin	46
Experiments with sugar beets at Fort Scott, Kansas	60
Analyses of beets at the Agricultural Experiment Station of Minnesota	60
Experiments with sugar beets at Topeka, Kansas	60
Experiments with sugar beets at Medicine Lodge, Kansas	61
Effect of soil on beet production	71
Culture of the Klein Wanzlebener original	72
Systematic study of the different varieties of sugar beets in Saxony	74
General conclusions	75
Appendix—Notes on sugar-beet culture in France and Germany. By Walter Maxwell	81

EXPERIMENTS WITH SUGAR BEETS IN 1890.

PURCHASE AND DISTRIBUTION OF SEEDS.

From Mr. Henry T. Oxnard, the Department purchased 3 tons of sugar-beet seed, of which the greater portion was the variety known as the Klein Wanzlebener, grown by Dippe Brothers, of Quedlinburg. In addition to this, however, smaller quantities of the White Improved Vilmorin were purchased, together with the varieties of beets grown by Lemaire, Simon Legrand, Florimond, and Bulteau Desprez. These different varieties were put in one-pound packages and sent to over one thousand different persons who had made special inquiry for them. Accompanying these packages were directions for preparing the soil and planting and cultivating the beets. Directions were also sent for harvesting and sampling the beets and for sending samples to the Department for analysis. Nearly one thousand samples of beets were received by the Department, of which the analyses were made and the results communicated to the farmers sending them. In addition to this work a large number of the beet plots were personally inspected by agents of the Department, and particular inquiry was directed to a large number of farmers in regard to the methods of cultivation which they had pursued.

Only in a few instances were the directions of the Department followed out to the letter. In most cases the planting and cultivation of the beet seed were conducted according to such methods as the agriculturist might hit upon at the time. From the information gathered it was found that the chief variation from the instructions was in the preparation of the soil. In very few cases was a subsoil plow used and most of the beets which were sent to the Department were evidently grown in soil of insufficient depth. In some cases, where the exact directions for cultivation were carried out, the character of the beets received showed by contrast with the others the absolute necessity of employing the best methods of agriculture for their production.

It was not thought best the first year to make any effort to obtain from the farmers the exact yield of their beets per acre. The difficulty of securing such information is almost insurmountable. In the first place the amount of land under cultivation is usually guessed at, and in very few cases are exact measurements made. The results, therefore,

at best are only estimates unless the absolute control of measurements and weights can be secured. It was thought best, therefore, to depend for estimates of yield upon the actual quality of the beets produced, since it is well known that about 40,000 beets of fair quality can be produced upon an acre. It is therefore fair to presume that the yield per acre would be, within ordinary limits, the weight of the average beet sent for analysis multiplied by 40,000. When, however, it is necessary to speak of the beets weighing over one pound the rule no longer holds good, as it would be evidently impracticable to grow 40,000 beets of such a size upon an acre. It is fair, however, to estimate the yield upon beets weighing about 1 pound at 40,000 per acre or 20 tons. It is not meant by this that a yield of 20 tons can be obtained by farmers at the beginning, for this is not the case; it is only exceptionally that such a yield can be secured. When, however, the exact methods of beet culture are thoroughly understood and the method of fertilizing and preparing the soil studied, it will not be difficult, with favorable climatic conditions, to secure a yield of beets equal to 20 tons per acre.

EXPERIMENTS AT FACTORIES.

By the courtesy of the managers of the company the Department was permitted to station a chemist at Grand Island, who had charge of the sampling of the beets as they came to the factory in wagons or carloads. Nearly three thousand analyses of samples were made and the full tabulated reports of these analyses will be found following. The proprietors of the factory were so encouraged by the season's work that they have decided to erect another large factory at Norfolk, Nebraska, and at the Chino Ranch in southern California, and work on these factories is now going on.

Manufacturing experiments, on a small scale, with sugar beets, were also carried on during the season just past at Medicine Lodge, Kansas. About 80 acres of beets in all were harvested for the factory, and a summary of the work done will be given in another place.

FINANCIAL RETURNS TO BEET-GROWERS.

In general, the following remarks may be made concerning the last season's work in the beet-sugar industry, from a commercial point of view, in Nebraska and Kansas.

The summer in both localities was exceptionally dry. For this reason and on account of lack of knowledge among the farmers in regard to the proper methods of raising beets the average crop was very short. In Nebraska the exact tonnage can not be known, but probably it would not average more than 2 or 3 tons of beets per acre; in Kansas the average seems to have been somewhat higher. In many cases farmers obtained 10 and even 15 tons of beets per acre, showing that even in adverse conditions of season a reasonably large crop may be harvested when all other conditions necessary to the proper growth of the crop are attended to.

As might well be expected from the small yield, the farmers in general were dissatisfied with the season's work. It is not reasonable to expect satisfaction from a crop of so low an average when the labor of growing it is so great; but while the farmers are dissatisfied it must be confessed that a great deal of this dissatisfaction must be attributed to their own lack of knowledge of the subject or to their disinclination to put upon the beet fields the proper amount of labor and culture at the proper time. Instead of being therefore deterred from continuing the production of sugar beets, it would seem wiser on the part of the farmers to study carefully the methods of agriculture pursued by those who made a success of beet culture, and to imitate those methods during the coming season. The fact should not be forgotten, however, that even with the poor results obtained the beet crop was uniformly better than the average of other crops in the same locality.

It would be useless to hold out to the farmer the hope of financial reward from a beet crop which would average only 3 tons per acre; but if from this acre he could produce 10 to 15 tons of beets then his venture would prove financially successful. In order that the manufacture of beet sugar should become an established commercial success, the factories and the farmers must work in harmony. The method pursued in France and in Germany would probably be best suited to bring about this result. In those countries the beet growers themselves are usually shareholders in the factories, and thus participate in the profits. It is probable that the annual dividends of German and French beet-sugar factories do not fall below 10 per cent net on the capital invested. The farmer, therefore, who has even a small interest in such a factory secures a handsome profit on his invested capital. At the same time he has a vote in the board of directors and is personally interested in the success of the factory. In many factories of Europe the stock is thus held by the beet-growers. If, on the other hand, the whole of the factory be owned by the capitalists, then there is a cause for continual conflict between the interests of the farmer and the interests of the manufacturer, although this conflict is perhaps more in theory than practice. Even if the factory be owned exclusively by the capitalists, it is to their interest to work in harmony with the farmers, in order that they may secure a crop of sufficient magnitude to render the operation of their factory profitable.

It perhaps, however, would be unavoidable at the beginning of the industry that a feeling of animosity should exist between the beet-grower and the manufacturer. After a few years the prices to be paid for beets and other agreements with the farmers will doubtless be adjusted on a scale of equity and satisfaction to all concerned. In case farmers have no money to put into beet-sugar factories they might take shares of stock and pay for them with beets during the first and second years; in this way they would secure a financial interest in the company, own their shares of stock, and pay for them from the proceeds of the field without investing in ready cash. By adopting some such plan

as this it might be possible to get every beet-grower within reach of the factory to become himself interested as a stockholder.

ANALYTICAL DATA RELATING TO BEETS GROWN FROM SEED PURCHASED BY THE DEPARTMENT.

The samples of beets which were sent to the Department in response to the request already noted were immediately analyzed and the results of the analyses communicated to the growers of the beets. Returns were received from a great many States, but principally from Nebraska and Minnesota.

The data obtained follow arranged alphabetically by States and counties:

CALIFORNIA.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coeff. cent.	Ash.	Average weight of beets.
Los Angeles County.									
University of California.	7616	Excelsior	Sept. 27	<i>P. ct.</i> 16.3	<i>P. ct.</i> 15.5	84.5	18.1	<i>P. ct.</i> .90	<i>Gr'ms.</i> 407
Do.	7617	Imperial	Sept. 27	14.9	14.2	80.5	15.1	.99	372
Do.	7618	Imperial Improved	Sept. 27	13.9	13.2	82.2	12.4	1.12	397
Do.	7619	Vilmorin	Sept. 27	16.8	16.0	87.0	17.9	.94	352
Average .....		.....	.....	15.5	14.7	84.6	15.9	.99	382

COLORADO.

<i>Garfield County.</i>										
A. J. Saint	7956	Klein Wanzlebener ..	Oct. 23	13.7	13.0	74.1	9.9	1.39		405
<i>Larimer County.</i>										
C. S. Crandal	8035	Bulteau Desprez	Oct. 27	16.0	15.2	86.0	16.9	.95		395
Do.	8036	do.	Oct. 27	15.5	14.7	84.7	16.3	.95		460
Do.	8037	Vilmorin	Oct. 27	13.6	12.9	76.8	13.7	.99		1,320
Do.	8038	Klein Wanzlebener ..	Oct. 27	15.9	15.1	86.0	16.7	.95		805
Do.	8039	Florimond Desprez ..	Oct. 27	16.2	15.4	84.4	18.0	.90		475
Do.	8040	Simon Legrand	Oct. 27	12.1	11.5	80.2	12.9	.94		665
Wm. Boyce	8096	Lane's Imperial	Nov. 1	13.4	12.7	81.3	14.1	.95		390
Average				14.7	14.0	83.2	15.5	.95		644
<i>Mesa County.</i>										
H. R. Rhone	8073		Oct. 30	15.2	14.4	86.4	13.0	1.17		453
<i>Phillips County.</i>										
C. R. Peters	7766	Florimond Desprez ..	Oct. 10	12.6	12.0	69.9	8.5	1.49		533
Do.	7767	Klein Wanzlebener ..	Oct. 10	14.6	13.8	74.9	10.5	1.39		755
Mrs. M. Peters	7785	Florimond Desprez ..	Oct. 10	13.7	13.0	71.0	7.1	1.90		620
Average				13.6	12.9	71.9	8.7	1.62		638
<i>Prowers County.</i>										
A. R. Black	7789	Colorado Imperial ..	Oct. 11	9.6	9.1	66.2	5.8	1.67		533
Do.	7793	California Legrand ..	Oct. 11	9.2	8.7	67.6	5.7	1.61		606
Do.	7794	Florimond Desprez ..	Oct. 11	11.6	11.0	71.6	10.7	1.08		590
Do.	7795	Colorado Vilmorin ..	Oct. 11	8.4	8.0	64.1	5.0	1.69		463
Do.	7796	Klein Wanzlebener ..	Oct. 11	12.7	12.1	74.7	8.4	1.52		403
Average				10.3	9.8	68.8	7.1	1.51		519

COLORADO—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
<i>Pueblo County.</i>									
Pueblo Board of Trade	8177	.....	Nov. 8	<i>P. ct.</i> 11.4	<i>P. ct.</i> 10.8	76.5	8.8	<i>P. ct.</i> 1.30	<i>Gr'ss.</i> 515
Do	8178	.....	Nov. 8	15.5	14.7	82.9	13.3	1.17	650
Do	8179	.....	Nov. 8	15.9	15.1	84.1	14.0	1.12	580
Do	8180	.....	Nov. 8	15.4	14.6	83.7	14.3	1.08	485
Do	8181	.....	Nov. 8	12.3	11.7	77.9	7.8	1.57	545
Do	8182	.....	Nov. 8	10.6	10.1	70.2	10.3	1.03	690
Average .....		.....		13.5	12.8	79.2	11.4	1.21	578
<i>San Miguel County.</i>									
C. F. Truax	8264	Vilmorin	Nov. 17	9.5	9.0	65.5	7.5	1.26	875
Do	8265	.....	Nov. 17	11.3	10.7	66.1	7.4	1.53	765
Average .....		.....		10.4	9.9	65.8	7.5	1.40	820
<i>Fuma County.</i>									
H. Hitchcock	7871	Klein Wanzlebener	Oct. 15	12.6	12.1	75.9	10.4	1.21	720
Do	7872	.....	Oct. 15	8.2	7.8	63.1	6.8	1.21	425
Average .....		.....		10.4	9.9	69.5	8.6	1.21	573
<i>County unknown.</i>									
C. W. Zepp	8055	Simon Legrand	Oct. 29	15.7	14.9	79.7	12.1	1.30	333
Do	8113	Klein Wanzlebener	Nov. 3	19.2	18.2	.....	13.3	1.44	93
Average .....		.....		17.4	16.5	79.7	12.7	1.37	213

CONNECTICUT.

<i>Litchfield County.</i>									
W. H. Barber	7939	German Imperial	Oct. 21	10.8	10.3	76.1	7.1	1.53	410
Do	7940	.....	Oct. 21	9.6	9.1	76.2	7.6	1.26	390
Average .....		.....		10.2	9.7	76.1	7.4	1.40	400

IDAHO.

<i>Ada County.</i>									
N. F. Kimball	7970	.....	Oct. 24	8.4	8.0	68.3	9.0	1.21	100

ILLINOIS.

<i>Kendall County.</i>									
Peter Solomon	8029	.....	Oct. 27	7.2	6.5	64.9	7.0	1.03	832
<i>Pike County.</i>									
Fred Epker	8170	.....	Nov. 7	10.7	10.2	71.8	7.9	1.35	1,368
<i>Flatt County.</i>									
G. H. Morse	8410	.....	Nov. 22	6.4	6.1	61.0	4.3	1.48	685
<i>Will County.</i>									
J. W. Merrill	7787	White Sugar	Oct. 10	10.8	10.3	67.6	10.0	1.09	645
Henry Abbott	8108	do	Nov. 3	7.9	7.7	65.3	7.8	0.99	775
E. McAllister	8266	French Richest	Nov. 17	15.9	15.1	85.0	16.1	0.99	600
Do	8267	do	Nov. 17	14.7	14.0	83.7	14.3	1.03	1,445
S. Mottinger	8299	German Imported	Nov. 20	13.3	12.6	77.3	11.4	1.17	686
Average .....		.....		12.5	11.9	75.8	11.9	1.05	830

INDIANA.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline co-efficient.	Ash.	Average weight of beets.
<i>Benton County.</i>									
Thos. Schluttenhafer.	7373	Vilmorin	Sept. 22	<i>P. ct.</i> 12.6	<i>P. ct.</i> 12.0	79.2	16.4	.77	252
Do.	7374	Klein Wanzlebener	Sept. 22	11.0	10.4	73.3	12.9	.85	322
H. W. Wiley	7607	do	Sept. 26	12.5	11.9	81.7	15.4	.81	417
Do.	7775	.....	Oct. 10	12.1	11.5	78.0	13.3	.91	500
Do.	7777	.....	Oct. 10	9.8	9.3	69.0	11.9	.82	470
Do.	7925	.....	Oct. 20	13.9	13.2	88.5	12.4	1.25	535
Do.	7912	.....	Oct. 22	13.9	13.2	84.8	14.6	.95	413
Do.	8017	.....	Oct. 27	13.4	12.7	95.0	16.5	.81	690
Do.	8422	.....	Nov. 25	14.6	13.9	81.1	16.3	.90	687
Joseph Gnetter	7778	.....	Oct. 10	11.6	11.0	75.8	10.5	1.11	1115
Ole Olson	7945	Green Top	Oct. 22	8.5	8.1	66.9	6.3	1.35	1250
J. G. Bozemore	8072	White Sugar	Oct. 30	12.6	12.0	79.7	10.4	1.21	1320
John Patterson	8074	.....	Oct. 30	12.2	11.6	73.5	12.3	.99	517
John Kaar	8079	.....	Oct. 31	14.2	13.5	85.6	17.5	.81	900
J. H. Schott	8081	.....	Oct. 31	13.8	13.1	85.7	16.7	.81	515
N. B. Nutt	8136	.....	Nov. 5	15.0	14.2	87.7	15.8	.95	823
Oliver Nutt	8137	.....	Nov. 5	13.5	12.8	84.4	18.8	.77	733
G. S. Kaar	8080	.....	Oct. 31	13.2	12.5	84.1	15.3	.86	665
Joseph Gnetter	7779	.....	Oct. 10	12.2	11.6	80.8	12.8	.95	1115
Average	.....	.....	.....	12.6	12.0	80.8	14.0	0.94	697
<i>Cass County.</i>									
Henry Bloom	7670	Klein Wanzlebener	Oct. 4	14.6	13.9	88.0	22.1	.66	680
Do.	7671	Florimond Desprez	Oct. 4	10.3	9.8	77.4	13.9	.74	810
G. W. Conrad	7952	.....	Oct. 22	10.4	9.9	73.8	7.2	1.44	1100
M. L. Spiee	8274	.....	Nov. 17	14.1	14.1	66.4	8.6	1.71	410
Westly Stauffer	8275	.....	Nov. 17	15.1	14.3	63.8	8.8	1.71	300
Jas. Bell	8276	.....	Nov. 17	13.3	12.6	61.9	6.4	2.07	450
Average	.....	.....	.....	13.1	12.4	71.9	11.2	1.39	625
<i>Clinton County.</i>									
John Betts	8273	.....	Nov. 17	19.1	18.1	78.9	14.7	1.30	430
<i>Decatur County.</i>									
G. W. Snyder	7362	Klein Wanzlebener	Sept. 18	5.6	5.3	58.9	4.8	1.17	1840
<i>Grant County.</i>									
H. D. Thomas	7734	Klein Wanzlebener	Oct. 8	9.8	9.3	73.7	9.9	.99	675
Do.	7735	Imperial	Oct. 8	9.3	8.8	70.8	7.3	1.28	583
Do.	7736	Florimond Desprez	Oct. 8	8.3	7.9	68.0	6.5	1.27	665
Snead Thomas	8449	.....	Dec. 5	9.6	9.1	72.2	9.3	1.03	695
Do.	8450	Imperial	Dec. 5	8.2	7.8	66.7	6.1	1.35	885
Average	.....	.....	.....	9.0	8.6	70.3	7.8	1.18	701
<i>Green County.</i>									
L. D. Maddux	8152	Klein Wanzlebener	Nov. 6	15.4	14.6	.....	12.7	1.21	220
Do.	8153	Lemaire's Improved	Nov. 6	12.7	12.1	77.9	10.9	1.17	385
Average	.....	.....	.....	14.1	13.4	77.9	11.8	1.19	303
<i>Hamilton County.</i>									
A. Smith	8283	.....	Nov. 19	10.3	9.8	72.5	7.6	1.35	605
Ira W. Christian	8421	.....	Nov. 24	11.1	10.5	66.9	6.3	1.75	407
Average	.....	.....	.....	10.7	10.2	69.7	7.0	1.55	506
<i>Hancock County.</i>									
S. Caroway	7371	Legrand White Impr.	Sept. 22	11.1	10.5	75.4	12.3	0.90	445
Do	7372	Klein Wanzlebener	Sept. 22	3.5	3.3	28.2	3.2	1.08	990
Average	.....	.....	.....	7.3	6.9	51.8	7.8	0.99	718
<i>Henry County.</i>									
P. Hayse	8123	.....	Nov. 3	11.2	10.6	82.6	11.2	1.00	789

INDIANA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
<i>Howard County.</i>									
Dr. T. Baldwin.....	8277	.....	Nov. 17	<i>P. ct.</i> 13.9	<i>P. ct.</i> 13.2	70.5	8.8	<i>P. ct.</i> 1.57	<i>Gr'ms.</i> 600
<i>Marion County.</i>									
J. H. Bradford.....	7782	Florimond Desprez ..	Oct. 10	6.4	6.1	60.3	4.4	1.44	940
Do.....	7783	Klein Wanzlebener ..	Oct. 10	9.8	9.3	72.1	9.0	1.09	935
J. V. Carter.....	7933	Lemaire.....	Oct. 20	8.1	7.7	64.3	6.4	1.26	565
Do.....	7934	Klein Wanzlebener ..	Oct. 20	8.2	7.8	.....	5.5	1.48	430
Dr. J. P. Cope.....	7950	do.....	Oct. 22	16.2	15.4	.....	8.3	1.98	115
Do.....	7951	Florimond Desprez ..	Oct. 22	13.5	12.8	.....	9.1	1.48	300
Average.....	.....	.....	.....	10.4	9.8	65.6	7.1	1.46	548
<i>Montgomery County.</i>									
P. S. Kennedy.....	7740	.....	Oct. 8	7.9	7.5	63.2	7.4	1.07	855
Do.....	7741	.....	Oct. 8	8.3	7.9	65.6	7.8	1.06	1,050
Average.....	.....	.....	.....	8.1	7.7	64.4	7.6	1.07	953
<i>Newton County.</i>									
J. E. Watt.....	7946	White.....	Oct. 22	10.6	10.1	72.1	8.4	1.26	475
Do.....	7947	White Rose Heart ..	Oct. 22	10.4	9.9	71.2	8.3	1.26	610
Average.....	.....	.....	.....	10.5	10.0	71.7	8.4	1.26	543
<i>Pike County.</i>									
J. T. Brumfield.....	7370	Klein Wanzlebener ..	Sept. 22	11.2	10.5	75.7	11.8	0.95	432
<i>Tippecanoe County.</i>									
W. A. Conklin.....	7919	Lemaire.....	Oct. 20	8.2	7.8	61.2	6.1	1.35	605
Do.....	7920	Klein Wanzlebener ..	Oct. 20	9.3	8.8	67.9	8.6	1.08	600
Average.....	.....	.....	.....	8.8	8.3	64.6	7.4	1.21	603
<i>White County.</i>									
Wm. Love.....	7747	White Improved.....	Oct. 9	7.8	7.4	63.4	6.0	1.31	630
Do.....	7748	Klein Wanzlebener ..	Oct. 9	9.4	8.9	65.3	10.0	0.99	250
Z. C. Love.....	7755	White Improved.....	Oct. 9	8.8	8.4	61.1	6.4	1.38	750
Average.....	.....	.....	.....	8.7	8.2	63.3	7.5	1.23	543

IOWA.

<i>Audubon County.</i>									
Mrs. S. Simpson.....	7909	.....	Oct. 18	11.3	10.7	74.9	8.7	1.30	535
<i>Black Hawk County.</i>									
Bozarth Bros.....	7770	.....	Oct. 10	12.9	12.3	83.2	13.0	.99	510
Do.....	7771	.....	Oct. 10	10.8	10.3	74.5	9.6	1.12	740
Do.....	7772	Klein Wanzlebener ..	Oct. 10	14.5	13.8	80.1	19.3	.75	550
Do.....	7773	do.....	Oct. 10	12.9	12.3	78.6	14.3	.90	605
J. A. Fellers.....	7774	do.....	Oct. 10	13.6	12.9	71.5	14.5	.94	440
Do.....	7775	do.....	Oct. 10	15.9	15.1	81.5	18.1	.88	625
Average.....	.....	.....	.....	13.4	12.8	78.2	14.5	.93	578
<i>Carroll County.</i>									
G. Wattles.....	7898	.....	Oct. 17	14.6	13.9	81.6	15.5	.94	810
Do.....	7899	.....	Oct. 17	10.9	10.4	67.3	8.1	1.34	985
Henry Silvers.....	8020	Vilmorin.....	Oct. 27	12.4	11.8	74.7	10.2	1.21	640
August Bohme.....	8021	do.....	Oct. 27	15.5	14.7	85.2	14.4	1.08	213
Daniel Cooper.....	8078	do.....	Oct. 30	12.7	12.1	73.4	10.1	1.26	265
Average.....	.....	.....	.....	13.2	12.6	76.4	11.7	1.17	583

IOWA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline co-efficient.	Ash.	Average weight of beets.
<i>Cherokee County.</i>									
F. M. Langley	7692	Klein Wanzlebener ...	Oct. 6	<i>P. ct.</i> 9.7	<i>P. ct.</i> 9.2	63.4	6.4	1.52	440
Do.	7693	do.	Oct. 6	12.1	11.5	72.9	9.9	1.22	507
Average				10.9	10.4	68.2	8.2	1.57	474
<i>Fayette County.</i>									
J. W. Yeadon	7602	Klein Wanzlebener ...	Sept. 25	10.4	9.9	71.7	9.3	1.12	752
G. W. Kiple	7605	do.	Sept. 25	13.3	12.6	79.6	12.9	1.03	747
Average				11.9	11.3	75.7	11.1	1.08	750
<i>Harrison County.</i>									
R. Yeisley & Son	7642		Sept. 30	13.9	13.2	79.4	11.4	1.22	1,002
Do.	7737		Oct. 8	8.8	8.4	66.7	5.6	1.57	1,027
Average				11.4	10.8	73.1	8.5	1.40	1,013
<i>Page County.</i>									
J. A. Johnson	7954	Brabant	Oct. 23	11.7	11.1	72.6	11.8	.99	668
<i>Polk County.</i>									
H. Wendt	8270	Florimond Desprez ...	Nov. 17	6.1	5.8	56.0	3.7	1.66	430
Do.	8271	Klein Wanzlebener ...	Nov. 17	10.7	10.2	.....	7.7	1.39	280
Average				8.4	8.0	56.0	5.7	1.53	355
<i>Sioux County.</i>									
N. G. O. Coad	7703		Oct. 6	12.4	11.8	71.7	8.1	1.50	298
Do.	7704		Oct. 6	10.7	10.2	69.0	7.3	1.47	1,045
John Cornforth	8016		Oct. 27	13.6	12.9	77.3	10.1	1.35	1,020
Average				12.2	11.6	72.7	8.5	1.44	788
<i>Webster County.</i>									
R. Hoff	7892	Vilmorin	Oct. 16	15.9	15.1	95.2	18.3	.81	320
Do.	8172	do.	Nov. 8	18.1	17.2	87.5	23.5	.77	220
Do.	8173	do.	Nov. 8	17.6	16.7	91.1	25.9	.68	520
Do.	8174	do.	Nov. 8	8.7	8.3	65.4	6.4	1.35	1,180
Average				15.1	14.4	84.8	18.5	.90	560
<i>Woodbury County.</i>									
Mrs. H. A. Mercer	7638	Klein Wanzlebener ...	Sept. 29	10.0	9.5	68.5	7.7	1.30	665
Do.	7639	Vilmorin	Sept. 29	10.4	9.9	65.4	6.8	1.53	590
Average				10.2	9.7	67.0	7.3	1.42	628

KANSAS.

<i>Barber County.</i>									
W. H. Fleming	8432		Dec. 1	14.6	13.9	81.1	14.2	1.03	259
O. Coyle	8433		Dec. 1	17.8	16.9	84.8	17.3	1.03	140
Allan W. Smith	8434		Dec. 1	14.1	13.4	74.2	11.7	1.21	690
Average				15.5	14.7	80.0	14.4	1.09	363
<i>Bourbon County.</i>									
Wm. Lehman	8106	German beet	Nov. 3	6.5	6.2	61.3	4.5	1.44	1,645
Do.	8107	American beet	Nov. 3	9.5	9.0	72.0	7.9	1.21	1,925
J. C. Hart	8160	White Vilmorin	Nov. 7	13.5	12.8	86.6	13.6	.69	610
Average				9.8	9.3	73.3	8.7	1.21	1,403

KANSAS—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
<i>Butler County.</i>									
L. R. Smith.....	7879	Florimond Desprez....	Oct. 15	<i>P. ct.</i> 10.2	<i>P. ct.</i> 9.7	70.5	8.4	<i>P. ct.</i> 1.21	<i>Gr mrs.</i> 685
<i>Lyon County.</i>									
Sen. P. B. Plumb.....	7385	.....	Sept. 24	4.9	4.7	50.0	3.3	1.50	2,130
Do.....	7386	.....	Sept. 24	4.2	4.0	51.2	3.1	1.35	2,695
Average.....				4.6	4.4	50.6	3.2	1.43	2,423
<i>Clay County.</i>									
Mrs. C. W. Blacklund.....	7722	Klein Wanzlebener....	Oct. 6	10.9	10.4	.....	7.1	1.53	162
Do.....	7723	Florimond Desprez....	Oct. 6	9.5	9.0	70.3	6.5	1.46	232
E. B. Marian.....	7750	do.....	Oct. 10	8.5	8.1	64.8	6.3	1.36	1,010
Do.....	7751	Simon Legrand.....	Oct. 10	10.4	9.9	68.0	7.2	1.44	1,040
Average.....				9.8	9.3	67.6	6.8	1.45	611
<i>Douglas County.</i>									
S. D. Coffin.....	8423	Klein Wanzlebener....	Nov. 25	8.5	8.1	65.3	5.2	1.62	1,385
Do.....	8424	do.....	Nov. 25	9.2	8.7	64.8	5.3	1.75	965
Average.....				8.9	8.4	65.1	5.3	1.68	1,175
<i>Hamilton County.</i>									
A. L. Bandy.....	8041	Klein Wanzlebener....	Oct. 28	15.7	14.9	82.2	13.8	1.12	720
Do.....	8042	Florimond Desprez....	Oct. 28	10.9	10.4	71.3	7.8	1.39	780
Average.....				13.3	12.6	76.8	10.8	1.26	750
<i>Johnson County.</i>									
Geo. B. Lord.....	7810	Klein Wanzlebener....	Oct. 13	9.3	8.8	68.4	7.1	1.31	410
Do.....	7811	Vilmorin.....	Oct. 13	16.8	16.0	.....	12.2	1.38	180
Average.....				13.05	12.4	68.4	9.7	1.35	295
<i>Saline County.</i>									
Ed. Latz.....	7666	Klein Wanzlebener....	Oct. 3	8.4	8.0	65.6	8.6	1.28	930
Do.....	7667	Florimond Desprez....	Oct. 3	8.2	7.8	60.7	8.1	1.01	847
Average.....				8.3	7.9	63.2	8.4	1.15	889
<i>Stafford County.</i>									
S. A. Marteeny.....	7815	Klein Wanzlebener....	Oct. 13	12.1	11.5	75.2	10.0	1.20	548

MARYLAND.

<i>Prince George's County.</i>									
Maryland Agricultural Experiment Station.	7882	Vilmorin.....	Oct. 16	12.3	11.7	82.0	15.2	.81	435
Do.....	7883	Simon Legrand White Improved.	Oct. 16	14.2	13.5	88.2	16.5	.86	480
Do.....	7884	Bulteau Desprez Rich-est.	Oct. 16	8.6	8.2	72.3	7.7	1.12	413
Do.....	7885	Florimond Desprez Rich-est.	Oct. 16	8.3	7.9	74.1	8.7	.95	433
Do.....	7886	Klein Wanzlebener...	Oct. 16	10.8	10.3	81.8	10.9	.99	445
Do.....	7984	Vilmorin.....	Oct. 25	10.4	9.9	77.0	9.6	1.08	265
Do.....	7985	Simon Legrand White Improved.	Oct. 25	7.9	7.5	70.2	7.3	1.08	355
Do.....	7986	Bulteau Desprez Rich-est.	Oct. 25	10.2	9.7	75.6	9.6	1.08	335
Do.....	7987	Florimond.....	Oct. 25	11.1	10.6	82.2	12.9	.86	425

MARYLAND—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
<i>Prince George's County—Continued.</i>				<i>P. ct.</i>	<i>P. ct.</i>			<i>P. ct.</i>	<i>Gr'sms.</i>
Maryland Agricultural Experiment Station.	7988	Klein Wanzlebener ...	Oct. 25	9.3	8.8	73.8	9.4	.99	540
Do.....	8057	Dippe's Vilmorin.....	Oct. 29	15.9	15.1	90.4	19.6	.81	383
Do.....	808	Simon Legrand White Improved.	Oct. 29	13.2	12.5	82.5	11.5	1.17	300
Do.....	8059	Bulteau Desprez Richest.	Oct. 29	8.6	8.2	73.5	8.0	1.08	580
Do.....	8060	Florimond Desprez Richest.	Oct. 29	10.0	9.5	76.9	8.9	1.12	320
Do.....	8061	Klein Wanzlebener ..	Oct. 29	11.1	10.6	78.2	10.5	.99	380
Do.....	8097	Dippe's Vilmorin.....	Nov. 1	10.5	10.0	69.0	6.9	1.53	330
Do.....	8098	Simon Legrand White Improved.	Nov. 1	12.5	11.9	86.8	12.1	1.03	320
Do.....	8099	Bulteau Desprez Richest.	Nov. 1	10.5	10.0	77.8	9.7	1.08	435
Do.....	8100	Florimond Desprez Richest.	Nov. 1	8.3	7.9	66.9	7.7	1.08	335
Do.....	8101	Klein Wanzlebener ...	Nov. 1	13.3	12.6	.....	13.4	.99	168
Do.....	8140	Dippe's Vilmorin.....	Nov. 5	14.6	13.9	.....	21.5	.68	155
Do.....	8141	Simon Legrand White Improved.	Nov. 5	14.5	13.8	.....	24.6	.59	195
Do.....	8142	Bulteau Desprez Richest.	Nov. 5	12.7	12.1	.....	16.5	.77	153
Do.....	8143	Florimond Desprez Richest.	Nov. 5	12.6	12.0	.....	18.5	.68	163
Do.....	8144	Klein Wanzlebener ...	Nov. 5	13.2	12.5	.....	16.3	.81	140
Do.....	8161	Dippe's Vilmorin.....	Nov. 7	13.2	12.5	84.6	18.3	.72	198
Do.....	8162	Simon Legrand White Improved.	Nov. 7	13.6	12.9	81.4	18.9	.72	170
Do.....	8163	Bulteau Desprez Richest.	Nov. 7	11.5	10.9	82.2	13.4	.86	137
Do.....	8164	Florimond Desprez Richest.	Nov. 7	12.5	11.9	82.3	17.4	.72	183
Do.....	8165	Klein Wanzlebener ...	Nov. 7	13.4	12.7	.....	15.6	.86	120
Do.....	8200	Dippe's Vilmorin.....	Nov. 12	15.4	14.6	.....	26.1	.59	170
Do.....	8201	Simon Legrand White Improved.	Nov. 12	14.1	13.4	.....	19.6	.72	135
Do.....	8202	Bulteau Desprez Richest.	Nov. 12	12.6	12.0	.....	15.6	.81	136
Do.....	8203	Florimond Desprez Richest.	Nov. 12	14.9	14.2	.....	23.6	.63	103
Do.....	8204	Klein Wanzlebener ...	Nov. 12	13.3	12.6	.....	18.5	.72	173
Do.....	8224	Vilmorin.....	Nov. 15	13.1	12.5	80.8	12.8	1.08	605
Do.....	8225	Simon Legrand White Improved.	Nov. 15	11.0	10.5	78.0	9.8	1.12	760
Do.....	8226	Bulteau Desprez Richest.	Nov. 15	10.4	9.4	76.5	8.6	1.21	830
Do.....	8227	Florimond Desprez Richest.	Nov. 15	9.8	9.3	74.8	10.3	.95	645
Do.....	8228	Klein Wanzlebener ...	Nov. 15	10.7	10.2	76.5	11.4	.94	370
Do.....	8229	Dippe's Vilmorin.....	Nov. 15	15.1	14.4	83.9	15.9	.95	385
Do.....	8230	Simon Legrand White Improved.	Nov. 15	14.9	14.2	83.2	16.4	.90	285
Do.....	8231	Bulteau Desprez Richest.	Nov. 15	13.7	13.0	82.5	14.4	.95	275
Do.....	8232	Florimond Desprez Richest.	Nov. 15	7.9	7.5	69.9	8.8	.90	530
Do.....	8233	Klein Wanzlebener ...	Nov. 15	12.1	11.5	78.6	10.8	1.12	255
Do.....	8234	Dippe's Vilmorin.....	Nov. 15	13.4	12.7	84.3	16.5	.81	320
Do.....	8235	Simon Legrand White Improved.	Nov. 15	14.3	13.6	80.8	15.0	.95	122
Do.....	8236	Bulteau Desprez Richest.	Nov. 15	12.1	11.5	82.3	14.1	.86	163
Do.....	8237	Florimond Desprez Richest.	Nov. 15	11.0	10.5	.....	15.3	.72	125
Do.....	8238	Klein Wanzlebener ...	Nov. 15	14.9	14.2	.....	19.4	.77	100
Do.....	8239	Dippe's Vilmorin.....	Nov. 15	13.0	12.4	83.3	14.4	.90	450
Do.....	8240	Simon Legrand White Improved.	Nov. 15	9.9	9.4	75.6	11.1	.90	305
Do.....	8241	Bulteau Desprez Richest.	Nov. 15	12.2	11.6	75.8	10.4	1.17	390

MARYLAND—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Prince George's County—Continued.</i>									
Maryland Agricultural Experiment Station.	8242	Florimond Desprez Richest.	Nov. 15	<i>P. ct.</i> 10.9	<i>P. ct.</i> 10.4	76.3	11.0	<i>P. ct.</i> .99	<i>Grms.</i> 335
Do.....	8243	Klein Wanzlebener ...	Nov. 15	13.1	12.5	84.0	12.7	1.03	305
Do.....	8244	Dippe's Vilmorin	Nov. 15	14.0	13.3	90.3	19.4	.72	145
Do.....	8245	Simon Legrand White Improved.	Nov. 15	14.2	13.5	.....	19.7	.72	155
Do.....	8246	Bulteau Desprez Richest.	Nov. 15	11.4	10.8	87.7	18.1	.63	350
Do.....	8247	Florimond Desprez Richest.	Nov. 15	11.2	10.6	80.0	14.5	.77	205
Do.....	8248	Klein Wanzlebener ...	Nov. 15	13.2	12.5	.....	17.1	.77	125
Do.....	8249	Vilmorin	Nov. 15	15.4	14.6	82.8	24.4	.63	555
Do.....	8250	Simon Legrand White Improved.	Nov. 15	12.6	12.0	77.8	12.7	.99	380
Do.....	8251	Bulteau Desprez Richest.	Nov. 15	13.7	13.0	81.1	17.8	.77	240
Do.....	8252	Florimond Desprez Richest.	Nov. 15	11.8	11.2	79.2	12.4	.95	220
Do.....	8253	Klein Wanzlebener ...	Nov. 15	12.3	11.7	78.4	15.2	.81	345
Do.....	8254	Dippe's Vilmorin	Nov. 15	15.1	14.4	86.3	19.6	.77	245
Do.....	8255	Simon Legrand White Improved.	Nov. 15	12.7	12.1	76.9	14.1	.90	260
Do.....	8256	Bulteau Desprez Richest.	Nov. 15	11.4	10.8	75.5	9.7	1.17	460
Do.....	8257	Florimond Desprez Richest.	Nov. 15	8.0	7.6	68.4	7.4	1.08	445
Do.....	8258	Klein Wanzlebener ...	Nov. 15	12.9	12.3	76.8	14.4	.90	190
Do.....	8259	do.....	Nov. 15	12.0	11.4	78.4	13.9	.86	200
Do.....	8260	Florimond Desprez Richest.	Nov. 15	12.2	11.6	73.5	12.3	.99	240
Do.....	8438	Dippe's Vilmorin	Dec. 4	22.0	21.0	.....	34.9	.63	90
Do.....	8439	Bulteau Desprez Richest.	Dec. 4	18.4	17.5	.....	23.9	.77	40
Do.....	8440	Florimond Desprez....	Dec. 4	20.0	19.0	.....	27.8	.72	58
Do.....	8441	Klein Wanzlebener	Dec. 4	19.8	18.8	.....	22.0	.90	63
Do.....	8442	Dippe's Vilmorin	Dec. 4	19.9	18.9	94.8	20.9	.95	375
Do.....	8443	Simon Legrand White Improved.	Dec. 4	17.6	16.7	91.2	19.6	.90	213
Do.....	8444	Bulteau Desprez Richest.	Dec. 4	17.8	16.9	84.8	19.8	.90	163
Do.....	8445	Florimond Desprez Richest.	Dec. 4	13.6	12.9	83.4	12.6	1.08	238
Do.....	8446	Klein Wanzlebener ...	Dec. 4	17.4	16.5	.....	17.6	.99	125
Average.....	.....	.....	.....	12.9	12.3	79.7	15.1	.90	416
J. H. Williams.....	8175	Sugar beet	Nov. 8	10.0	9.5	69.4	8.3	1.21	415
Do.....	8176	Extra Eclipse.....	Nov. 8	8.9	8.5	60.1	7.6	1.17	253
Average.....	.....	.....	.....	9.5	9.0	64.7	8.0	1.19	334

MASSACHUSETTS.

<i>Hampshire County.</i>									
Massachusetts State Experiment Station.	8030	Simon Legrand White Imp.	Oct. 27	11.1	10.6	81.6	13.7	.81	430
Do.....	8031	Dippe's Vilmorin.....	Oct. 27	11.8	11.2	80.3	12.4	.95	518
Do.....	8032	Klein Wanzlebener ...	Oct. 27	13.3	12.6	86.9	14.9	.90	340
Do.....	8033	Bulteau Desprez Richest.	Oct. 27	9.8	9.3	80.7	10.3	.95	458
Do.....	8034	Florimond Desprez....	Oct. 27	13.2	12.5	84.7	16.3	.81	595
Average.....	.....	.....	.....	11.8	11.2	82.8	13.5	.88	468
<i>Suffolk County.</i>									
W. H. Tenney & Co..	8139	.....	Nov. 5	16.8	16.0	82.8	17.0	.99	350

MICHIGAN.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coeff. cient.	Ash.	Average weight of beets.
<i>Clinton County.</i>									
George Archer	7887	Klein Wanzlebener ...	Oct. 16	<i>P. ct.</i> 12.9	<i>P. ct.</i> 12.3	81.7	15.9	<i>P. ct.</i> .81	<i>Gr'ms.</i> 745
Do	7888	Florimond Desprez Richest.	Oct. 16	11.2	10.6	72.7	15.6	.72	780
Average				12.1	11.5	77.2	15.8	.77	763
<i>Eaton County.</i>									
D. J. McCargan	8278	Florimond Desprez ...	Nov. 18	9.0	8.6	.....	8.7	1.03	167
Do	8279	Klein Wanzlebener ...	Nov. 18	10.2	9.7	.....	10.3	.99	207
Average				9.6	9.1	.....	9.5	1.01	187
<i>Gratiot County.</i>									
William Howe	7989	Klein Wanzlebener ...	Oct. 25	14.6	13.9	.....	14.8	.99	550
Do	7990	do	Oct. 25	13.7	13.0	.....	12.0	1.17	300
C. Boyd	8212	do	Nov. 14	9.3	8.8	70.5	9.0	1.03	1,750
Do	8213	Simon Legrand	Nov. 14	14.0	13.3	80.9	14.1	.99	1,470
Average				12.9	12.3	75.7	12.5	1.05	1,018
<i>Huron County.</i>									
W. P. Hatheway	7855	Klein Wanzlebener ...	Oct. 13	11.7	11.1	74.7	9.8	1.20	1,282
<i>Ingham County.</i>									
William Potter	8269	Klein Wanzlebener ...	Nov. 17	13.1	12.5	76.6	10.3	1.26	1,515
<i>Ionia County.</i>									
Dr. E. J. Howe	7696	Lemaire	Oct. 6	17.7	16.8	84.7	21.6	.82	387
Do	7706	Klein Wanzlebener ...	Oct. 6	14.2	13.5	81.1	14.2	1.00	443
Average				16.0	15.2	82.9	17.9	.91	415
<i>Lenawee County.</i>									
W. R. Osborn	7902	White Sugar	Oct. 17	8.6	8.2	60.6	8.7	.99	2,475
Do	7903	do	Oct. 17	8.2	7.8	60.3	10.1	.81	1,910
Average				8.4	8.0	60.5	9.4	.90	2,193
<i>Macomb County.</i>									
J. S. Lawson	8047	Klein Wanzlebener ...	Oct. 29	16.8	16.0	89.8	28.5	.59	680
Do	8048	Simon Legrand	Oct. 29	15.5	14.7	85.2	18.0	.86	705
Average				16.2	15.4	87.5	23.3	.73	693
<i>Muskegon County.</i>									
M. B. Averill	7633	Florimond Desprez ...	Sept. 29	10.0	9.5	70.4	8.3	1.21	365
Do	7634	Klein Wanzlebener ...	Sept. 29	14.2	13.4	80.2	14.3	.99	297
Jno. McNitt	7643	do	Oct. 1	13.7	13.0	80.5	17.8	.77	415
Do	7644	Florimond Desprez ...	Oct. 1	11.8	11.2	80.8	13.7	.86	542
Wm. Hartmann	7676	do	Oct. 4	12.9	12.3	81.7	11.0	1.17	400
Henry Paulman	7677	Florimond Desprez ...	Oct. 4	13.8	13.1	85.2	18.7	.74	735
Do	7678	Klein Wanzlebener ...	Oct. 4	14.3	13.6	85.1	20.1	.71	1,045
Do	7690	do	Oct. 4	12.7	12.1	83.0	14.6	.87	1,015
Orange Daggett	7971	Florimond Desprez ...	Oct. 24	9.9	9.4	78.5	10.4	.95	1,450
Do	7972	Klein Wanzlebener ...	Oct. 24	10.6	10.1	75.7	8.8	1.21	1,070
J. R. Devenport	8284	Russian	Nov. 19	16.4	15.6	89.1	17.2	.95	355
Average				12.8	12.2	80.9	14.1	.95	699
<i>St. Clair County.</i>									
Fritz Sagato	8431	do	Dec. 1	10.5	99.8	71.5	8.3	1.21	1,660
<i>Saginaw County.</i>									
J. D. Clarke	7999	Klein Wanzlebener ...	Oct. 25	14.2	13.5	87.1	17.5	.81	720
Do	8112	Florimond Desprez ...	Nov. 3	12.9	12.3	76.8	11.9	1.08	825
Average				13.6	12.9	82.0	14.7	.95	773

MINNESOTA.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Anoka County.</i>									
John Hunter	7658		Oct. 2	<i>P. ct.</i> 12.3	<i>P. ct.</i> 11.7	75.5	10.1	<i>P. ct.</i> 1.19	<i>Gr. ms.</i> 440
Do	7659		Oct. 2	15.9	15.1	84.1	17.2	.93	680
S. Barstow	7705		Oct. 6	14.9	14.2	85.0	16.4	.91	735
John Hunter	7707		Oct. 6	16.3	15.5	82.3	18.3	.89	387
L. J. Carpenter	7708		Oct. 6	12.0	11.3	76.4	11.3	1.06	607
F. A. Edgerton	7712	Klein Wanzlebener	Oct. 6	14.1	13.4	77.0	16.6	.85	407
A. J. Smith	7715		Oct. 6	13.5	12.9	76.2	14.5	.93	750
S. A. Farrington	7716		Oct. 6	10.5	10.0	63.6	7.2	1.45	617
Joseph Ridge	7717	Klein Wanzlebener	Oct. 6	10.8	10.3	74.5	10.8	1.14	590
Edward Stack	8006	do	Oct. 27	12.7	12.1	72.6	11.2	1.14	1,160
Average				13.3	12.6	76.72	13.4	1.05	637
<i>Becker County.</i>									
Hans Jagers	8062	Sugar	Oct. 30	15.0	14.3	77.3	11.8	1.26	1,060
Do	8063	do	Oct. 30	13.7	13.0	74.9	12.7	1.08	1,200
Do	8064	French sugar	Oct. 30	9.7	9.2	68.8	6.6	1.48	1,970
Average				12.8	12.2	73.7	10.4	1.27	1,410
<i>Blue Earth County.</i>									
B. W. Sower	7608	Klein Wanzlebener	Sept. 26	13.4	12.7	80.2	13.2	.99	480
Do	7609	Florimond Desprez	Sept. 26	11.3	10.7	76.8	11.4	.99	500
Do	7610	Klein Wanzlebener	Sept. 26	10.9	10.4	74.1	9.7	1.12	587
F. W. Lossow	7629	Florimond Desprez	Sept. 29	7.9	7.6	60.3	6.5	1.21	1,135
Do	7630	Lemaire Richest	Sept. 29	11.4	10.8	77.6	11.1	1.03	955
Chas. Bennett	7649	do	Oct. 10	11.5	10.9	73.2	9.0	1.28	523
Do	7650	Florimond Desprez	Oct. 10	10.6	10.1	74.1	9.6	1.11	693
Gilbert Guttersen	7918		Oct. 18	11.1	10.6	76.1	12.3	.90	509
Average				11.0	10.5	74.1	10.4	1.08	684
<i>Brown County.</i>									
Herman Pfander	7660	Florimond Desprez	Oct. 3	7.7	7.4	66.4	7.3	1.06	1,370
Do	7665	Klein Wanzlebener	Oct. 3	10.1	9.5	69.7	7.8	1.29	945
Average				8.9	8.5	68.1	7.6	1.18	1,158
<i>Carver County.</i>									
Leonhard Ziermann	7753	Klein Wanzlebener	Oct. 9	15.8	15.0	81.0	15.2	1.04	503
Do	7754	Florimond Desprez	Oct. 9	13.2	12.5	77.5	12.7	1.04	642
G. Tenbert	7968	Bohemian	Oct. 24	9.2	8.7	65.7	6.4	1.44	1,610
Do	7969		Oct. 24	8.2	7.8	60.0	4.8	1.71	1,020
Average				11.6	11.0	71.1	9.8	1.31	951
<i>Chisago County.</i>									
Eric Jonason	7631	Klein Wanzlebener	Sept. 29	12.2	11.6	75.3	10.4	1.17	680
Do	7632	Florimond Desprez	Sept. 29	15.1	14.4	79.5	14.0	1.08	495
L. J. Stark	7866		Oct. 14	13.8	13.1	80.2	15.2	.91	650
Do	7867		Oct. 14	12.7	12.1	80.9	9.8	1.30	1,265
L. O. Tomblor	7933		Oct. 24	13.9	13.2	83.7	15.4	.90	1,525
Average				13.5	12.9	79.9	12.9	1.07	923
<i>Clay County.</i>									
C. B. Kittredge	8205	Klein Wanzlebener	Nov. 12	13.6	12.9	73.9	9.1	1.48	865
Do	8430		Dec. 1	13.7	13.0	76.5	13.3	1.03	665
Average				13.7	13.0	75.2	11.2	1.26	765
<i>Cottonwood County.</i>									
Simon Huntington	8007	Florimond Desprez	Oct. 27	15.6	14.8	72.9	10.8	1.44	675
Do	8008	do	Oct. 27	10.3	9.8	62.4	5.9	1.75	1,120
Average				13.0	12.3	67.7	8.4	1.60	898

MINNESOTA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
<i>Dakota County.</i>									
H. W. Koch.....	8110	German sugar.....	Nov. 3	<i>P. ct.</i> 16.7	<i>P. ct.</i> 15.9	84.4	14.3	<i>P. ct.</i> 1.17	<i>Gr' ms.</i> 400
Do.....	8111	French sugar.....	Nov. 3	14.0	13.3	77.8	9.0	1.44	333
Average.....				15.3	14.6	81.1	11.6	1.31	367
<i>Faribault County.</i>									
C. H. Culver.....	8459	.....	Dec. 6	9.6	9.1	66.2	6.3	1.53	880
Do.....	8460	.....	Dec. 6	10.9	10.4	63.0	5.2	2.11	865
Average.....				10.3	9.8	64.6	5.8	1.82	873
<i>Fillmore County.</i>									
Dr. C. H. Robbins.....	7812	Simon Legrand.....	Oct. 13	9.7	9.2	56.0	5.9	1.64	1,262
D. J. Tew.....	8114	Brabant.....	Nov. 3	14.2	13.7	83.2	15.2	.95	390
Average.....				12.0	11.4	74.6	10.5	1.30	826
<i>Goodhue County.</i>									
Edward A. Donnell.....	7788	Klein Wanzlebener.....	Oct. 11	16.9	16.1	86.7	18.2	.93	447
William Hagman.....	8125	White sugar.....	Nov. 4	8.2	7.8	63.1	5.5	1.48	1,025
J. G. Stearns.....	8188	Klein Wanzlebener.....	Nov. 10	10.5	10.0	75.6	9.0	1.17	930
George W. Judd.....	8189	do.....	Nov. 10	8.9	8.5	63.6	7.4	1.25	815
Mrs. James Guero.....	8190	do.....	Nov. 10	11.7	11.1	64.4	7.9	1.48	390
R. P. Thacher.....	8416	do.....	Nov. 24	12.7	12.1	73.4	7.8	1.62	520
Average.....				11.5	10.9	71.1	9.3	1.32	685
<i>Hennepin County.</i>									
Olaf Johnson.....	7948	.....	Oct. 22	14.7	14.0	92.5	14.9	.99	780
Hans Burlingame.....	7949	.....	Oct. 22	12.5	11.9	69.4	8.2	1.53	940
George Dawthwaite.....	8132	Klein Wanzlebener.....	Nov. 4	9.4	8.9	68.6	7.5	1.26	1,560
Do.....	8133	Florimond Desprez.....	Nov. 4	9.7	9.2	69.8	7.5	1.30	576
Peter Weinand.....	8151	Simon Legrand.....	Nov. 6	16.5	15.7	79.3	15.3	1.08	817
William H. Loverin.....	8171	Klein Wanzlebener.....	Nov. 8	15.6	14.8	87.2	15.8	.99	600
Average.....				13.1	12.4	77.8	11.5	1.19	1,216
<i>Houston County.</i>									
Herman Pederson.....	7620	Klein Wanzlebener.....	Sept. 20	13.7	13.0	80.6	12.7	1.08	510
<i>Isant County.</i>									
Gaulbey & Anderson.....	8196	.....	Nov. 11	10.9	10.4	67.9	8.7	1.26	1,445
N. A. Ahlstrom.....	7790	Klein Wanzlebener.....	Oct. 11	9.8	9.3	68.0	6.6	1.48	1,925
Do.....	7791	Simon Legrand.....	Oct. 11	10.8	10.3	75.5	8.9	1.24	1,500
Average.....				10.5	10.0	70.5	8.1	1.33	1,623
<i>Le Sueur County.</i>									
J. C. Swain.....	7798	.....	Oct. 11	11.8	11.2	74.2	8.8	1.34	500
Do.....	7799	.....	Oct. 11	11.0	10.5	71.9	13.6	.61	515
Average.....				11.4	10.8	73.2	11.2	1.08	508
<i>Lincoln County.</i>									
A. J. Crain.....	8104	Klein Wanzlebener.....	Nov. 3	13.2	12.5	73.7	10.9	1.21	1,513
Do.....	8105	Florimond Desprez.....	Nov. 3	12.7	12.1	72.6	9.3	1.30	1,173
Average.....				13.0	12.3	73.2	10.4	1.26	1,343
<i>Lyon County.</i>									
Andrew De Sutter.....	8126	Klein Wanzlebener.....	Nov. 4	13.7	13.0	72.5	9.7	1.44	500
Do.....	8127	.....	Nov. 4	17.6	16.7	83.8	11.5	1.53	480
Average.....				15.7	14.9	78.2	10.6	1.49	490

MINNESOTA—Continued.

Name of grower.	Serial No	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline effluent.	Ash.	Average weight of beets.
<i>McLeod County.</i>									
Daniel Devitt.....	7651	Florimond Desprez	Oct. 2	<i>P. ct.</i> 10.0	<i>P. ct.</i> 9.5	69.4	7.5	1.34	<i>Gr' mrs.</i> 1,090
Do.....	7652	Richest. Klein Wanzlebener....	Oct. 2	13.0	12.3	77.9	12.7	1.02	795
Average				11.5	10.9	73.7	10.1	1.18	943
<i>Marshal County.</i>									
N. Bjorge	7657	Klein Wanzlebener....	Oct. 2	8.9	8.5	66.9	6.5	1.37	740
<i>Martin County.</i>									
William H. Budd	7877	Klein Wanzlebener....	Oct. 15	15.0	14.3	85.2	13.9	1.08	730
Do.....	7878	Florimond Desprez	Oct. 15	10.3	9.8	70.5	7.9	1.30	735
Nelson Bouse	7959	Klein Wanzlebener....	Oct. 23	12.9	12.3	76.4	9.6	1.35	725
Do.....	7960	Florimond Desprez....	Oct. 23	9.0	8.6	64.3	15.4	1.39	620
Henry Anderman	7963	.....	Oct. 23	12.7	12.1	76.5	10.9	1.17	850
William Suter	8070	.....	Oct. 30	9.0	8.4	64.7	6.5	1.39	1,670
Do.....	8071	.....	Oct. 30	13.4	12.7	77.0	9.3	1.44	895
Average				11.8	11.2	73.5	10.5	1.30	889
<i>Meeker County.</i>									
E. Evenson	7768	Lemaire.....	Oct. 10	11.1	10.6	74.0	9.0	1.24	515
Do.....	7769	Florimond Desprez....	Oct. 10	12.0	11.4	75.9	10.4	1.15	535
Average				11.6	11.0	75.0	9.7	1.15	525
<i>Murray County.</i>									
George B. Stiles	8076	.....	Oct. 30	13.3	12.4	86.1	12.0	1.08	600
Do.....	8077	.....	Oct. 30	12.6	12.0	84.6	11.3	1.12	440
V. H. Maxwell	8268	.....	Nov. 14	18.6	17.7	84.3	19.6	.95	279
James Taylor.....	8269	.....	Nov. 14	18.7	17.8	82.4	18.2	1.03	280
Do.....	8218	.....	Nov. 14	17.1	16.3	84.7	17.3	.99	475
Average				16.1	15.2	84.4	15.7	1.03	415
<i>Nicolet County.</i>									
Fritz Virth	7955	.....	Oct. 23	13.7	13.0	75.6	9.3	1.48	612
<i>Noble County.</i>									
J. P. Moulton	8092	White.....	Nov. 1	13.8	13.1	76.2	11.4	1.21	1,060
Do.....	8093	.....	Nov. 1	13.7	13.0	76.6	12.2	1.12	1,475
Average				13.8	13.1	76.4	11.8	1.17	1,268
<i>Pipestone County.</i>									
J. J. Barnard.....	8094	Holland	Nov. 1	10.3	9.8	67.4	7.6	1.35	933
Do.....	8095	.....	Nov. 1	12.9	12.3	74.6	10.2	1.26	1,375
Average				11.6	11.0	71.0	8.9	1.31	1,154
<i>Ramsey County.</i>									
Minnesota Experiment Station.	8287	Klein Wanzlebener	Nov. 20	11.2	10.6	81.8	13.8	.81	783
Do.....	8288	Bultea Desprez Rich- est.	Nov. 20	10.8	10.3	77.1	12.0	.90	990
Do.....	8289	Simon Legrand White Improved.	Nov. 20	10.9	10.4	74.2	14.2	.77	653
Do.....	8290	Dippe's Vilmorin.....	Nov. 20	12.9	12.3	89.6	19.0	.68	873
Do.....	8291	Florimond Desprez....	Nov. 20	9.4	8.7	83.2	12.2	.77	1,035
Do.....	8292	Vilmorin Sugar	Nov. 20	10.8	10.3	77.7	12.6	.86	635
Do.....	8293	White Sugar Gregory	Nov. 20	10.1	9.6	83.4	12.5	.81	770
Do.....	8294	Improved Imperial....	Nov. 20	8.0	7.6	74.8	9.3	.86	1,185
Do.....	8295	Excelsior Sugar	Nov. 20	11.3	10.7	82.7	12.6	.90	805
Do.....	8296	Lane's Gregory	Nov. 20	8.5	8.1	.....	7.9	.98	650
Do.....	8297	Lane's Improved Sugar	Nov. 20	9.9	9.4	80.5	10.4	.95	870
Do.....	8298	Vilmorin White Imp....	Nov. 20	9.7	9.2	86.1	10.2	.95	796
Average				11.1	10.6	81.0	12.2	.86	830

MINNESOTA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
<i>Rock County.</i>									
J. F. Shoemaker.....	8150	Klein Wanzlebener....	Nov. 6	<i>P. ct.</i> 14.2	<i>P. ct.</i> 13.5	79.3	12.7	<i>P. ct.</i> 1.12	<i>Gr'ns.</i> 870
<i>Steele County.</i>									
Clark Chambers.....	8027	Florimond Desprez....	Oct. 27	8.5	8.1	60.3	7.6	1.12	1,230
Do.....	8272	do.....	Nov. 17	11.0	10.5	74.8	8.7	1.26	855
Average.....				9.8	9.3	67.6	8.2	1.19	1,043
<i>Travers County.</i>									
H. C. Bartlet.....	8102	German Legrand.....	Nov. 3	18.3	17.4	79.2	14.1	1.30	840
Do.....	8103	do.....	Nov. 3	17.5	16.6	73.3	14.6	1.21	575
Average.....				17.9	17.0	76.3	14.4	1.26	708
<i>Wabash County.</i>									
John Ween.....	7641	Florimond Desprez ..	Sept. 29	10.3	9.8	71.0	7.1	1.44	280
<i>Washington County.</i>									
Roger S. McIntosh...	8018	Florimond Desprez....	Oct. 27	11.3	10.7	79.5	10.7	1.08	810
Do.....	8019	Klein Wanzlebener....	Oct. 27	13.6	12.9	80.5	13.5	1.03	710
Henry B. Voilner....	8169	French Beet.....	Nov. 7	11.7	11.1	69.2	7.7	1.53	1,790
Average.....				11.2	10.6	76.4	10.6	1.21	1103
<i>Wilkins County.</i>									
Robt. Glover.....	7606	Dutch.....	Sept. 24	15.4	14.6	80.6	15.6	.99	447
<i>Wright County.</i>									
C. W. Judson.....	7967	Klein Wanzlebener....	Oct. 24	10.5	10.0	71.4	8.1	1.30	910
<i>County unknown.</i>									
Henry Hillesheim ...	8437	.....	Dec. 2	6.6	6.3	61.7	4.6	1.44	2,053

MISSOURI.

<i>Bates County.</i>									
Jacob Blocher.....	7900	White Silesian.....	Oct. 17	9.1	8.7	66.9	8.4	1.08	500
Do.....	7901	French Sugar.....	Oct. 17	8.4	8.0	66.7	7.8	1.08	700
Average.....				8.8	8.4	66.7	8.2	1.08	600

NEBRASKA.

<i>Antelope County.</i>									
F. H. Trowbridge....	7366	.....	Sept. 22	16.1	15.3	82.1	16.9	.95	241
Do.....	7367	.....	Sept. 22	15.9	15.0	81.5	16.7	.95	226
Do.....	7368	.....	Sept. 22	16.6	15.8	88.8	16.1	1.03	176
Do.....	7369	.....	Sept. 22	18.8	17.9	81.8	18.3	1.03	119
C. A. Hathaway.....	7672	Florimond Desprez	Oct. 4	13.1	12.4	75.2	9.8	1.34	455
		Richest.							
Do.....	7673	Klein Wanzlebener ..	Oct. 4	14.1	13.4	.....	9.0	1.55	200
Do.....	7674	Florimond Desprez	Oct. 4	10.3	9.8	70.9	7.6	1.36	885
		Richest.							
Do.....	7675	Klein Wanzlebener ..	Oct. 4	16.0	15.3	.....	13.6	1.18	265
E. L. Heneway.....	7697	do.....	Oct. 6	14.3	13.4	77.3	11.1	1.29	755
Do.....	7698	Florimond Desprez....	Oct. 6	12.2	11.6	77.7	10.3	1.18	410
N. Cosby.....	7725	.....	Oct. 7	13.3	12.6	70.4	12.2	1.09	250
Do.....	7729	Improved White.....	Oct. 7	9.0	8.6	72.0	8.4	1.07	382

NEBRASKA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
<i>Antelope County—Continued.</i>				<i>P. ct.</i>	<i>P. ct.</i>			<i>P. ct.</i>	<i>Gr. ms.</i>
C. E. Heneway	7732	Klein Wanzlebener	Oct. 8	7.9	7.5	63.4	4.8	1.64	920
Do	7733	Florimond Desprez	Oct. 8	9.2	8.7	65.3	6.4	1.45	540
C. M. Wyman	7742	Klein Wanzlebener	Oct. 8	10.9	10.4	63.7	7.0	1.56	440
Do	7743	Florimond Desprez	Oct. 8	12.1	11.5	65.7	5.3	2.28	430
James Lewelan	7751	Do	Oct. 9	10.6	10.1	50.2	7.8	1.36	357
Do	7752	Do	Oct. 9	10.9	10.4	.....	8.8	1.24	170
George Brokaw	7863	Do	Oct. 14	10.7	10.2	68.2	11.5	.93	491
W. H. Cormeny	7997	Florimond Desprez	Oct. 25	16.5	15.7	86.4	16.7	.99	380
Do	7998	Do	Oct. 25	10.3	9.8	76.8	13.5	1.08	280
Carl Roben	8086	Do	Oct. 31	14.6	13.9	78.1	13.0	1.12	680
Do	8087	Simon Legrand	Oct. 31	13.9	13.2	79.8	12.9	1.08	520
Do	8088	Klein Wanzlebener	Oct. 31	13.6	12.9	80.5	14.3	.95	565
Do	8089	Desprez	Oct. 31	12.5	11.9	73.6	9.0	1.39	490
Do	8090	Lemaire	Oct. 31	14.6	13.9	.....	11.2	1.30	350
Do	8091	Lane's Imperial	Oct. 31	13.1	12.5	.....	9.4	1.39	320
E. Adams	8109	Vilmorin	Nov. 3	16.7	15.9	80.7	10.0	1.67	400
K. C. Edwards	8115	Do	Nov. 3	14.4	13.7	81.4	12.9	1.12	458
Average				13.2	12.5	74.7	10.2	1.26	419
<i>Banner County.</i>									
Wm. Everett	7392	French Beet	Sept. 24	10.8	10.3	66.2	8.3	1.30	710
Do	7393	Do	Sept. 24	11.4	10.8	68.3	10.6	1.08	693
Thos. H. Wilson	8026	Vilmorin	Oct. 27	14.0	13.3	76.9	9.7	1.44	435
Average				12.1	11.4	70.4	9.5	1.27	612
<i>Blaine County.</i>									
H. Heitholt	8051	Klein Wanzlebener	Oct. 29	14.6	13.9	78.1	11.6	1.26	610
Do	8052	Florimond Desprez	Oct. 29	11.9	11.3	74.4	9.4	1.26	550
Average				13.3	12.6	76.3	10.5	1.26	580
<i>Boone County.</i>									
C. D. Dean	7819	Desprez	Oct. 13	9.1	8.6	68.6	6.3	1.45	350
Do	7820	Lemaire	Oct. 13	8.1	7.7	65.3	5.5	1.48	435
Anton Ankle	7821	Simon Legrand	Oct. 13	13.3	12.6	72.2	10.3	1.30	685
Do	7822	Lemaire	Oct. 13	13.3	12.6	71.6	12.7	1.05	995
Lewis Leslie	7823	Do	Oct. 13	12.8	12.2	73.6	10.3	1.24	820
Do	7824	Simon Legrand	Oct. 13	11.4	10.8	67.8	10.2	1.12	500
Do	7825	Klein Wanzlebener	Oct. 13	14.3	13.6	88.3	11.7	1.22	820
Do	7826	Desprez	Oct. 13	10.7	10.2	.....	7.8	1.54	515
Do	7827	Lemaire	Oct. 13	10.1	9.6	67.3	6.9	1.46	720
J. B. Green	7828	Do	Oct. 13	7.6	7.2	57.6	4.3	1.77	445
Do	7829	Simon Legrand	Oct. 13	8.8	8.3	62.8	4.9	1.78	545
Do	7830	Klein Wanzlebener	Oct. 13	9.5	9.0	65.9	5.9	1.60	735
J. E. Green	7831	Desprez	Oct. 13	8.7	8.2	65.4	5.3	1.64	485
T. C. Williams	7832	Do	Oct. 13	11.9	11.3	.....	10.8	1.18	225
Do	7833	Simon Legrand	Oct. 13	14.2	13.5	.....	11.5	1.23	340
Do	7834	Klein Wanzlebener	Oct. 13	8.9	8.5	71.2	8.2	1.09	645
Do	7835	Desprez	Oct. 13	8.1	7.7	62.3	4.4	1.86	410
Do	7836	Lemaire	Oct. 13	11.7	11.1	75.0	10.9	1.07	585
G. M. Limard	7837	Do	Oct. 13	10.7	10.2	68.2	10.0	1.07	725
Do	7838	Simon Legrand	Oct. 13	10.3	9.8	66.0	9.0	1.15	765
Do	7839	Klein Wanzlebener	Oct. 13	13.3	12.6	76.8	10.1	1.21	765
Do	7840	Desprez	Oct. 13	11.7	11.1	74.7	15.0	.78	740
Do	7841	Lemaire	Oct. 13	12.0	11.4	81.1	12.0	1.00	640
M. G. Curtis	7842	Do	Oct. 13	12.3	11.7	.....	10.5	1.17	280
Do	7843	Simon Legrand	Oct. 13	13.2	12.5	.....	10.5	1.26	270
Do	7844	Klein Wanzlebener	Oct. 13	10.8	10.4	.....	7.1	1.53	365
Do	7845	Desprez	Oct. 13	12.4	11.8	.....	8.2	1.51	165
Do	7846	Do	Oct. 13	11.4	10.8	72.2	8.5	1.34	510
H. H. Howard	7847	Simon Legrand	Oct. 13	8.8	8.4	62.3	5.9	1.50	590
Do	7848	Klein Wanzlebener	Oct. 13	8.2	7.8	63.5	5.6	1.46	630
Do	7849	Desprez	Oct. 13	9.2	8.7	64.5	12.5	.74	670
Ed. Popper	7850	Do	Oct. 13	9.9	9.4	70.7	8.1	1.23	595
Do	7851	Simon Legrand	Oct. 13	11.4	10.8	76.5	11.5	.99	405
Do	7852	Klein Wanzlebener	Oct. 13	10.1	9.6	71.2	9.0	1.12	455
Do	7853	Desprez	Oct. 13	9.6	9.1	63.2	7.9	1.24	790
Do	7854	Lemaire	Oct. 13	7.0	6.6	62.1	5.1	1.37	620
Average				10.7	10.1	69.2	8.7	1.29	550

NEBRASKA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Box Butte County.</i>									
A. S. Darling	7746	Vilmorin	Oct. 9	<i>P. ct.</i> 12.9	<i>P. ct.</i> 12.3	72.5	9.3	<i>P. ct.</i> 1.39	<i>Gr'ms.</i> 825
Do.	7765	Klein Wanzlebener ..	Oct. 10	14.4	13.7	76.2	10.6	1.39	820
P. W. Tracy	7801	do.	Oct. 11	15.0	14.3	68.5	10.0	1.50	407
M. W. Nye	7802	Florimond	Oct. 11	10.3	9.8	69.1	7.4	1.40	513
J. A. Heist	7803	Klein Wanzlebener ..	Oct. 11	14.7	14.0	69.4	10.1	1.45	650
H. W. Axtell	8009	Klein Wanzlebener, Dippe's.	Oct. 27	9.7	9.2	74.0	8.0	1.21	785
Average				12.8	12.2	71.6	9.2	1.39	666
<i>Brown County.</i>									
W. H. Carey	7868	Desprez	Oct. 10	10.6	10.1	69.7	7.0	1.51	350
<i>Butler County.</i>									
Elizabeth Bales	7668	Lemaire Legrand	Oct. 3	12.6	12.0	68.9	10.9	1.16	260
Do.	7669	do.	Oct. 3	14.0	13.3	.....	11.8	1.19	230
Average				13.3	12.7	68.9	11.4	1.18	245
<i>Chase County.</i>									
E. J. Ledger	7744	.....	Oct. 8	10.5	10.0	70.5	8.4	1.25	1380
Do.	7745	.....	Oct. 8	12.1	11.5	63.5	9.2	1.31	725
Miss D. Vroman	8042	Florimond Desprez, Richest.	Oct. 29	10.0	9.5	66.2	8.3	1.21	860
Do.	8013	Klein Wanzlebener ..	Oct. 29	11.5	10.9	69.7	7.5	1.53	855
Peter Jones	8214	Florimond Desprez ..	Oct. 29	13.9	13.2	73.5	9.4	1.48	708
Do.	8215	Klein Wanzlebener ..	Oct. 29	13.7	13.0	74.1	9.5	1.44	675
Lizzie Jones	8206	Florimond Desprez ..	Nov. 14	14.3	13.6	74.9	9.7	1.48	540
Do.	8207	Klein Wanzlebener ..	Nov. 14	13.9	13.2	72.4	7.9	1.75	630
Average				12.4	11.7	70.6	8.7	1.43	796
<i>Cherry County.</i>									
John Benning	7376	Vilmorin	Sept. 24	9.0	8.6	55.2	4.5	2.00	455
Do.	7377	.....	Sept. 24	9.7	9.2	65.8	5.2	1.85	603
Average				9.4	8.9	60.5	4.9	1.92	530
<i>Colfax County.</i>									
H. M. Kemp	7880	.....	Oct. 15	10.3	9.8	65.3	6.6	1.57	1,025
Do.	7881	.....	Oct. 15	10.9	10.4	70.3	6.9	1.57	850
John Schult	8001	Klein Wanzlebener ..	Oct. 25	13.6	12.9	77.3	11.2	1.21	500
J. B. Martin	8010	Dippe's Vilmorin	Oct. 27	15.4	14.6	81.9	14.3	1.08	523
Do.	8011	.....	Oct. 27	13.0	12.4	75.1	10.0	1.30	686
Joseph Praisler	8130	Florimond Desprez	Nov. 4	11.3	10.7	62.4	5.2	2.16	500
Do.	8131	Klein Wanzlebener ..	Nov. 4	12.4	11.8	66.7	7.3	1.71	540
Average				12.4	11.8	71.3	8.8	1.51	661
<i>Cuming County.</i>									
Uriah Bruner	7907	Klein Wanzlebener ..	Oct. 18	10.8	10.3	67.9	8.3	1.30	475
Do.	7908	Florimond Desprez ..	Oct. 18	10.9	10.4	71.7	8.7	1.26	910
Average				10.9	10.4	69.8	8.5	1.28	692
<i>Custer County.</i>									
W. O. Porter	7663	Vilmorin	Oct. 3	7.9	7.5	60.8	6.0	1.32	565
Do.	7664	do.	Oct. 3	8.8	8.4	.....	5.4	1.63	305
J. D. Haskell	7679	.....	Oct. 4	7.4	7.0	61.7	5.5	1.35	575
Do.	7680	.....	Oct. 4	5.6	5.3	52.3	2.9	1.96	575
Average				7.4	7.0	58.2	5.0	1.56	550
<i>Dawes County.</i>									
R. P. Gregg	7974	Florimond Desprez Richest.	Oct. 24	10.4	9.9	69.3	7.2	1.44	246
Do.	7975	Klein Wanzlebener ..	Oct. 24	16.2	15.4	72.7	8.4	1.93	290
W. J. Hooker	8056	Vilmorin White	Oct. 29	13.7	13.0	77.9	9.5	1.44	340
Average				13.4	12.7	73.3	8.3	1.60	258

NEBRASKA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Dawson County.</i>									
Mrs. Ella Stanley....	7927	Klein Wanzlebener ...	Oct. 20	<i>P. ct.</i> 10.8	<i>P. ct.</i> 10.3	69.7	6.7	<i>P. ct.</i> 1.62	<i>Gr'ms.</i> 840
Do.....	7928	do.....	Oct. 20	11.3	10.7	76.9	6.3	1.71	500
Average.....				11.0	10.5	73.3	6.5	1.66	670
<i>Deuel County.</i>									
G. W. Hultz	8028	Klein Wanzlebener ...	Oct. 27	19.8	18.8	.....	12.2	1.62	248
<i>Dodge County.</i>									
E. Morell	7941	Vilmorin	Oct. 21	14.9	14.2	81.4	13.8	1.08	750
Chas. Osterman.....	8124	.....	Nov. 4	16.3	15.5	83.2	15.8	1.03	450
Average.....				15.6	14.8	82.3	14.8	1.05	600
<i>Dundy County.</i>									
F. B. Moore.....	8427	Klein Wanzlebener , Dippe's.	Nov. 28	10.5	10.0	67.7	8.3	1.26	1565
<i>Fillmore County.</i>									
J. S. Beardsly.....	7684	.....	Oct. 4	12.5	11.9	73.1	8.4	1.49	990
Do.....	7685	.....	Oct. 4	11.2	10.6	67.9	6.8	1.65	710
Do.....	7686	Klein Wanzlebener ...	Oct. 4	13.5	12.8	71.1	8.4	1.61	640
Do.....	7687	Desprez	Oct. 4	12.1	11.5	65.8	6.1	1.98	440
Do.....	7688	Lemaire.....	Oct. 4	10.9	10.4	65.6	7.0	1.55	605
Average.....				12.0	11.6	68.7	7.3	1.66	677
<i>Frontier County.</i>									
A. E. Hill.....	7856	.....	Oct. 13	9.8	9.3	66.7	7.5	1.31	895
Do.....	7857	Klein Wanzlebener ...	Oct. 13	12.9	12.3	66.8	11.3	1.14	355
Do.....	7858	Desprez.....	Oct. 13	12.0	11.4	72.3	9.5	1.22	435
G. L. Sherman.....	7859	.....	Oct. 13	11.2	10.6	70.9	8.5	1.32	535
Do.....	7860	Desprez.....	Oct. 25	17.1	16.3	85.9	16.4	1.04	490
W. F. Sherman.....	7993	Vilmorin Improved ..	Oct. 25	15.7	14.9	81.3	12.1	1.30	350
Do.....	7994	Klein Wanzlebener ...	Oct. 25	11.8	11.2	76.6	8.7	1.35	660
Average.....				12.9	12.3	74.4	10.5	1.24	531
<i>Furnas County.</i>									
H. Montgomery.....	7681	Klein Wanzlebener ...	Oct. 4	12.0	11.4	71.4	7.7	1.55	565
Do.....	7682	Florimond Desprez...	Oct. 4	13.0	12.4	74.7	9.4	1.39	247
W. B. Keith.....	7813	Klein Wanzlebener ...	Oct. 15	14.7	14.0	75.0	11.0	1.34	600
Do.....	7814	Florimond Desprez...	Oct. 15	13.2	12.5	77.2	11.6	1.14	605
H. Montgomery.....	7932	.....	Oct. 20	14.0	13.3	81.9	9.2	1.53	255
Average.....				13.4	12.7	76.0	9.8	1.39	454
<i>Gage County.</i>									
A. C. Wagner.....	7387	Klein Wanzlebener ...	Sept. 24	13.3	10.7	79.0	14.0	.81	610
Do.....	7388	do.....	Sept. 24	7.3	6.9	59.3	5.2	1.40	725
Do.....	7389	do.....	Sept. 24	12.0	11.4	6.55	13.3	.90	323
M. C. Blake.....	7702	Florimond Desprez...	Oct. 6	8.1	7.7	67.5	6.6	1.23	1,245
E. Arnold.....	8400	Vilmorin	Nov. 21	10.7	10.2	71.3	8.2	1.30	705
Do.....	8401	Klein Wanzlebener ...	Nov. 21	10.0	9.5	69.0	7.7	1.30	715
Average.....				9.9	9.4	68.6	9.2	1.16	721
<i>Garfield County.</i>									
T. Crane.....	7699	Florimond	Oct. 6	14.6	13.9	.....	11.3	1.29	260
Do.....	7700	do.....	Oct. 6	12.4	11.8	.....	9.9	1.26	265
M. O'Connor.....	7738	Vilmorin	Oct. 8	17.6	16.7	83.4	13.7	1.28	860
Do.....	7739	do.....	Oct. 8	13.4	12.7	82.5	11.7	1.15	700
M. Crane.....	7786	Florimond	Oct. 10	9.8	9.3	61.2	6.3	1.56	630
A. Phillips.....	7800	.....	Oct. 11	13.2	12.5	72.0	9.9	1.34	483
Average.....				13.3	12.8	74.8	10.5	1.31	533

NEBRASKA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
<i>Hall County.</i>									
Hans Stodt	7891		Oct. 16	<i>P. ct.</i> 16.4	<i>P. ct.</i> 15.6	90.6	13.5	<i>P. ct.</i> 1.21	<i>Gr ms.</i> 448
Fred Suchlisen	7893	German White	Oct. 16	17.5	16.6	87.1	17.7	.99	398
Average				16.9	16.1	88.8	15.6	1.10	423
<i>Hamilton County.</i>									
J. D. Evans	7655		Oct. 2	12.8	12.2		9.7	1.32	260
Do	7656		Oct. 2	15.1	14.4		13.1	1.15	210
Average				14.0	13.3		11.4	1.24	235
<i>Harlan County.</i>									
A. C. Robins	7383	Vilmorin	Sept. 24	12.2	11.6	70.2	9.9	1.25	255
Do	7384	Klein Wanzlebener	Sept. 24	13.1	12.5	71.1	10.5	1.25	166
Aug. Sasse	7904	do	Oct. 17	7.6	7.2	65.0	5.6	1.35	640
Do	7905	do	Oct. 17	11.9	11.3		10.6	1.12	255
Average				11.2	10.7	68.8	9.2	1.24	328
<i>Hayes County.</i>									
C. A. Ready	7816		Oct. 13	13.7	13.0	72.0	9.3	1.48	915
Do	7817		Oct. 13	17.3	16.4	79.7	12.5	1.39	590
Do	7818		Oct. 13	13.8	13.1	71.7	8.5	1.62	1,235
Average				14.9	14.2	74.5	10.1	1.49	913
<i>Hitchcock County.</i>									
Anthony Stark	7906	Klein Wanzlebener	Oct. 18	10.7	10.2	67.7	7.0	1.53	715
H. H. Taylor	8044	do	Oct. 28	13.1	12.5	72.0	8.6	1.53	380
Do	8045	Lemaire	Oct. 28	17.7	16.8	76.3	11.3	1.57	413
Do	8046	Desprez	Oct. 28	17.5	16.6	76.1	11.4	1.53	350
Average				14.7	14.0	73.0	9.6	1.54	464
<i>Holt County.</i>									
J. H. Gordon	7394		Sept. 24	9.0	8.6	66.2	7.1	1.26	1,945
Do	7395		Sept. 24	10.5	10.0	70.4	8.1	1.21	2,190
Thos. Wiggins	7694	Vilmorin	Oct. 6	14.1	13.4	75.8	11.3	1.25	600
Do	7695	do	Oct. 6	14.4	13.7	77.0	13.1	1.10	445
E. H. Benedict	7709	Klein Wanzlebener	Oct. 6	13.6	12.9	65.1	9.2	1.48	365
Do	7710	do	Oct. 6	19.8	18.8		12.7	1.56	205
Do	7711	do	Oct. 6	18.1	17.2		10.7	1.69	187
N. B. Bisbee	7713		Oct. 6	12.1	11.5	71.2	8.3	1.46	680
Do	7714	Vilmorin	Oct. 6	12.3	11.7	74.0	9.0	1.36	515
E. H. Benedict	7718	Florimond Desprez	Oct. 6	14.3	13.5		9.9	1.44	545
Do	7719	do	Oct. 6	14.8	13.8		6.7	2.23	177
Do	7720	do	Oct. 6	12.1	11.5	68.4	7.7	1.58	460
H. H. Saunders	7864		Oct. 14	12.5	11.9	75.8	10.0	1.23	1,690
Do	7865		Oct. 14	16.1	15.3	79.9	11.3	1.43	1,300
J. Gus. Kluck	7917		Oct. 18	13.1	12.5	80.9	10.8	1.21	860
W. B. Lower	8002	Imported White	Oct. 25	15.1	14.4	81.6	14.7	1.03	670
Edgar Bruner	8197		Nov. 11	20.4	19.4	73.9	10.8	1.89	220
Average				14.2	13.5	73.9	10.1	1.44	777
<i>Howard County.</i>									
C. T. Kenyon	7375	Klein Wanzlebener	Sept. 22	12.5	11.9	79.6	13.2	.95	810
<i>Jefferson County.</i>									
W. W. Watson	7910	Vilmorin	Oct. 18	11.6	11.0	69.5	8.0	1.44	328
Do	7911		Oct. 18	14.9	14.2	79.7	12.7	1.17	408
Do	7912	Lemaire	Oct. 18	12.2	12.6	72.2	9.0	1.35	365
Do	7913	Klein Wanzlebener	Oct. 18	13.1	12.5	74.9	9.4	1.39	450
Do	7914	Florimond Desprez	Oct. 18	9.5	9.1	63.3	6.4	1.48	655
A. Wilson	8414	Desprez	Nov. 24	13.3	12.6	72.3	9.2	1.44	413
J. G. Dougan	8415		Nov. 24	12.1	11.5	74.7	9.3	1.30	420
Average				12.4	11.8	72.4	9.1	1.37	434

NEBRASKA—Continued.

Name of grower.	Serial No.	Variety.	When received	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Kearney County.</i>									
Gus. Olson.....	7982	Klein Wanzlebener...	Oct. 24	<i>P. ct.</i> 15.6	<i>P. ct.</i> 14.8	76.1	13.3	<i>P. ct.</i> 1.17	<i>Gr'ms.</i> 214
C. D. Emerson.....	8447	Lemaire Richest.....	Dec. 4	22.8	21.7	.....	13.7	1.66	155
Do.....	8448	Klein Wanzlebener.....	Dec. 4	25.5	24.2	.....	14.6	1.75	303
Average.....				21.3	20.2	76.1	13.9	1.53	224
<i>Kimball County.</i>									
M. Newingle.....	7646	White Improved.....	Oct. 1	11.4	10.8	70.4	7.9	1.44	227
<i>Knox County.</i>									
H. S. Morton.....	7640		Sept. 29	15.3	14.5	81.4	13.1	1.17	595
Carl Schindler.....	7862		Oct. 14	7.8	7.4	62.2	5.9	1.32	2,010
William Bonner.....	7978	Klein Wanzlebener.....	Oct. 24	10.3	9.8	76.8	7.9	1.30	1,150
William Barnum.....	7979	do.....	Oct. 24	12.9	12.3	68.3	8.4	1.53	485
Do.....	7980	do.....	Oct. 24	10.2	9.7	68.5	9.0	1.35	100
Average.....				11.3	10.7	71.4	8.9	1.33	868
<i>Lincoln County.</i>									
Caspar Bolish.....	7358		Sept. 5	10.9	10.4	67.4	7.9	1.39	428
G. R. Gullera.....	7359		Sept. 5	12.7	12.1	73.9	12.3	1.04	177
W. S. Hawkins.....	7360		Sept. 5	14.1	13.4	70.5	11.4	1.24	236
Dr. Calvert.....	7361	Lane's Imperial.....	Sept. 6	5.8	5.5	60.4	4.9	1.18	90.0
T. Stimson.....	7611	Vilmorin.....	Sept. 26	12.5	11.8	76.7	10.7	1.17	877
C. C. Hawkins.....	7724	do.....	Oct. 7	13.9	13.2	79.4	14.9	.93	680
Do.....	7726	do.....	Oct. 7	12.9	12.3	77.2	10.8	1.19	710
J. Whiter.....	8000	Dippe's Vilmorin.....	Oct. 25	15.8	15.0	86.8	16.4	.90	900
J. H. Knowles.....	8268	Klein Wanzlebener.....	Nov. 17	19.8	18.8	82.8	14.7	1.35	515
Average.....				13.2	12.5	75.0	11.6	1.15	613
<i>Loup County.</i>									
H. W. Adams.....	7935	Florimond Desprez, Richest.	Oct. 21	10.5	10.0	67.3	6.0	1.75	675
Do.....	7936	do.....	Oct. 21	9.7	9.2	64.7	5.4	1.75	710
Average.....				10.1	9.6	66.0	5.7	1.75	692
<i>McPherson County.</i>									
D. P. Wilcox.....	7976	Klein Wanzlebener, Dippe's.	Oct. 24	11.7	11.1	75.0	11.8	.99	285
Do.....	7977	Florimond Desprez, Richest.	Oct. 24	14.3	13.6	77.3	11.3	1.26	190
Average.....				13.0	12.4	76.2	11.6	1.13	238
<i>Madison County.</i>									
D. R. Daniels.....	7921	Desprez.....	Oct. 20	10.4	9.9	71.7	8.9	1.17	580
Do.....	7922	do.....	Oct. 20	12.2	11.6	70.5	8.0	1.53	800
Do.....	7923	Vilmorin.....	Oct. 20	13.2	12.6	73.3	10.5	1.30	1,340
Do.....	7924	do.....	Oct. 20	11.2	10.6	72.7	8.6	1.30	655
T. J. Harter.....	7930	Klein Wanzlebener.....	Oct. 20	14.2	13.5	85.5	13.8	1.03	410
Average.....				12.2	11.6	74.7	10.0	1.26	523
<i>Nuckolls County.</i>									
G. G. Hedgecock.....	7378	Florimond Desprez, Richest.	Sept. 24	7.3	6.9	58.8	4.8	1.50	393
Do.....	7879	do.....	Sept. 24	10.8	10.3	69.2	9.0	1.20	390
Do.....	7380	Klein Wanzlebener, Dippe's.	Sept. 24	9.6	9.1	73.3	8.0	1.20	295
Do.....	7381	do.....	Sept. 24	8.2	7.8	68.3	6.6	1.25	320
Average.....				8.9	8.5	67.4	7.1	1.28	347

NEBRASKA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Pawnee County.</i>									
W. A. Hutchinson.....	7873	Desprez.....	Oct. 15	<i>P. ct.</i> 12.5	<i>P. ct.</i> 11.9	79.1	11.2	<i>P. ct.</i> 1.12	<i>Gr' mgs.</i> 1,038
Do.....	7874	Klein Wanzlebener ..	Oct. 15	12.4	11.8	79.5	11.5	1.08	768
T. E. Tackley.....	7937	Legrand.....	Oct. 21	12.7	12.1	81.9	10.5	1.21	532
Do.....	7938	Florimond Desprez ..	Oct. 21	15.6	14.8	83.4	14.5	1.08	432
Average.....				13.3	12.7	80.5	11.9	1.12	693
<i>Perkins County.</i>									
Miss D. Vroman.....	7627	Florimond Richest.....	Sept. 29	10.7	10.2	71.8	7.6	1.40	1,147
Do.....	7628	do.....	Sept. 29	9.5	9.0	68.8	7.0	1.35	1,040
C. H. Purinton.....	7915	Klein Wanzlebener ..	Oct. 18	16.5	15.7	79.3	12.7	1.30	955
Do.....	7916	Dippe's Richest.....	Oct. 18	11.4	10.8	70.8	7.7	1.48	945
Dan Neff.....	7973	Klein Wanzlebener ..	Oct. 24	18.0	17.1	90.5	15.4	1.17	630
M. H. Hudson.....	7653	do.....	Oct. 2	12.3	11.7	71.1	9.0	1.54	760
Do.....	7654	Klein Wanzlebener ..	Oct. 2	12.3	11.7	72.4	8.0	1.54	520
Average.....				13.0	12.4	74.9	9.6	1.40	857
<i>Phelps County.</i>									
J. P. Olson.....	8219	.....	Nov. 14	16.0	15.2	75.8	10.5	1.53	290
Do.....	8220	Simon Legrand.....	Nov. 14	12.7	12.1	67.9	6.6	1.94	360
Do.....	8221	Klein Wanzlebener ..	Nov. 14	11.9	11.3	66.9	6.2	1.93	490
Do.....	8222	Desprez.....	Nov. 14	11.2	10.6	70.4	6.9	1.62	255
Do.....	8223	Lemaire.....	Nov. 14	12.7	13.0	.....	9.3	1.48	130
Average.....				13.1	12.4	70.2	7.9	1.70	305
<i>Pierce County.</i>									
U. S. Forbes.....	7981	.....	Oct. 24	11.5	10.9	75.2	8.2	1.39	565
<i>Platte County.</i>									
Gerhard Ascke.....	8183	.....	Nov. 8	12.3	11.7	71.1	8.9	1.39	365
Do.....	8184	Simon Legrand.....	Nov. 8	10.1	9.5	.....	6.5	1.53	250
Do.....	8185	Klein Wanzlebener ..	Nov. 8	11.2	10.6	69.1	6.4	1.75	520
Do.....	8186	Lemaire Richest.....	Nov. 8	8.6	8.2	64.7	5.2	1.66	340
Average.....				10.6	10.0	68.3	6.8	1.58	369
<i>Polk County.</i>									
J. B. Dey.....	8003	Dippe's Vilmorin.....	Oct. 25	8.9	8.5	64.5	5.8	1.53	435
Do.....	8004	Florimond Desprez.....	Oct. 25	12.1	11.5	69.5	8.2	1.48	575
Do.....	8005	Klein Wanzlebener, Dippe's	Oct. 25	13.3	12.6	71.1	8.5	1.57	590
Average.....				11.4	10.9	68.4	7.5	1.53	533
<i>Red Willow County.</i>									
S. Bolles.....	7762	.....	Oct. 10	5.3	5.0	48.1	2.6	2.05	1,235
Do.....	7763	White sugar.....	Oct. 10	11.9	11.3	74.3	14.5	.82	645
Average.....				8.6	8.1	61.2	8.6	1.43	940
<i>Richardson County.</i>									
B. Semanton.....	8145	.....	Nov. 5	12.9	12.3	69.4	9.2	1.39	845
Do.....	8146	Simon Legrand.....	Nov. 5	10.9	10.4	66.2	10.6	1.03	639
Do.....	8147	Klein Wanzlebener ..	Nov. 5	10.2	9.7	66.2	6.1	1.67	740
Do.....	8148	Desprez.....	Nov. 5	7.4	7.0	59.7	5.9	1.26	815
Do.....	8149	Lemaire.....	Nov. 5	9.9	9.4	65.6	7.4	1.35	635
Average.....				10.3	9.8	65.4	7.8	1.34	733
<i>Rock County.</i>									
A. H. Gale.....	8211	Klein Wanzlebener ..	Nov. 14	15.2	14.4	83.1	12.1	1.26	400

NEBRASKA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Saline County.</i>									
F. J. Foss	8022	Florimond Desprez ..	Oct. 27	<i>P. ct.</i> 7.4	<i>P. ct.</i> 7.0	56.1	3.9	<i>P. ct.</i> 1.89	<i>Gr'ms.</i> 375
Do.	8023	Klein Wanzlebener ..	Oct. 27	9.1	8.6	64.1	5.1	1.80	475
Average				8.3	7.8	60.1	4.5	1.85	425
<i>Saunders County.</i>									
W. Meyer	7727	Vilmorin	Oct. 7	11.2	10.6	69.6	4.8	2.34	825
Do.	7728	do.	Oct. 7	10.8	10.3	74.5	10.3	1.05	730
J. Gabriel	8128		Nov. 4	17.7	16.8		17.2	1.63	305
Do.	8129		Nov. 4	15.3	14.5	83.2	14.9	1.03	370
Average				13.8	13.1	75.8	11.8	1.36	5,575
<i>Scott Bluff County.</i>									
William Gauser	8138		Nov. 5	23.9	22.7	83.3	15.6	1.5	333
<i>Seward County.</i>									
E. L. Blanchard	7382		Sept. 24	10.3	9.8	66.0	9.4	1.10	440
W. K. Kelley	7929	Vilmorin	Oct. 20	13.1	12.5	78.5	11.2	1.17	460
Average				11.7	11.2	72.3	10.3	1.14	450
<i>Sheridan County.</i>									
N. J. Cook	7623	Florimond Desprez ..	Sept. 27	9.3	8.8	68.4	5.7	1.62	455
Do.	7624	do.	Sept. 27	11.4	10.8	76.0	8.4	1.35	265
S. E. Ferguson	7625	do.	Sept. 27	14.7	14.0	77.3	10.2	1.44	485
Do.	7626	do.	Sept. 27	10.5	10.0	71.4	8.3	1.26	568
C. A. Watterman	8014	Klein Wanzlebener, Dippe's.	Oct. 27	9.2	8.7	68.7	7.3	1.26	663
Do.	8015	Florimond Desprez ..	Oct. 27	8.5	8.1	63.0	6.3	1.35	548
T. A. Fleming	8083		Oct. 31	7.5	7.1	54.7	4.4	1.71	700
Do.	8084		Oct. 31	19.6	18.6	78.7	12.5	1.57	500
A. Richardson	8085		Oct. 31	15.8	15.0		10.6	1.53	340
Average				11.8	11.2	69.8	8.2	1.45	503
<i>Thayer County.</i>									
W. B. Hughes	8191		Nov. 10	12.7	12.1	77.5	11.8	1.08	870
Do.	8192	Simon Legrand	Nov. 10	14.1	13.4	80.6	15.7	.90	1,060
Do.	8193	Klein Wanzlebener ..	Nov. 10	11.2	10.6	74.2	9.3	1.21	1,595
Do.	8194	Desprez	Nov. 10	13.6	12.9	76.4	11.2	1.21	645
Do.	8195	Lemaire	Nov. 10	14.2	13.5	84.5	13.2	1.08	1,020
C. E. Ward	8451	Improved White Sugar	Dec. 6	14.6	13.9	66.4	8.5	1.71	315
Do.	8452	Desprez	Dec. 6	12.7	12.1	71.8	8.8	1.44	403
Do.	8453	Klein Wanzlebener ..	Dec. 6	16.9	16.1	77.9	12.2	1.39	335
Do.	8454	Lemaire	Dec. 6	18.3	17.4	82.1	13.6	1.35	385
Do.	8455	Desprez	Dec. 6	17.1	16.2	83.2	13.6	1.26	292
Do.	8456	Klein Wanzlebener ..	Dec. 6	18.2	17.3	84.7	16.9	1.08	323
Do.	8457	Lemaire	Dec. 6	14.1	13.4	75.4	9.8	1.44	495
Do.	8458	Klein Wanzlebener ..	Dec. 6	15.9	15.1	76.4	5.5	1.62	500
Average				14.9	14.6	77.8	11.8	1.29	632
<i>Valley County.</i>									
E. W. Waterman	7804	Florimond Desprez ..	Oct. 11	10.2	9.7	68.9	7.0	1.45	460
Do.	7805	Klein Wanzlebener ..	Oct. 11	12.0	11.4	69.4	8.1	1.48	547
Average				11.2	10.6	69.7	7.6	1.46	503
<i>Wayne County.</i>									
D. W. C. Hood	7621	Dippe's	Sept. 21	9.6	9.1	73.5	7.4	1.30	325
Do.	7622	Klein Wanzlebener ..	Sept. 21	9.4	8.9	68.1	6.0	1.57	500
Average				9.5	9.0	70.8	6.7	1.44	413

NEBRASKA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>York County.</i>									
D. H. Reeder.....	8065	.....	Oct. 30	<i>P. ct.</i> 9.8	<i>P. ct.</i> 9.3	62.0	7.3	<i>P. ct.</i> 1.35	<i>Gr'ms.</i> 620
Do.....	8066	Simon Legrand.....	Oct. 30	13.9	13.2	73.9	10.3	1.35	450
Do.....	8067	Klein Wanzlebener ..	Oct. 30	14.4	13.7	75.8	11.1	1.30	590
Do.....	8068	Desprez.....	Oct. 30	14.7	14.0	75.0	13.1	1.12	530
Do.....	8069	Lemaire.....	Oct. 30	11.1	10.6	68.9	10.3	1.08	560
Henry Smith.....	8417	.....	Nov. 24	16.4	15.6	78.5	11.1	1.48	445
Do.....	8418	.....	Nov. 24	15.4	14.6	.....	9.5	1.62	210
Do.....	8419	.....	Nov. 24	14.6	13.9	72.6	8.8	1.66	230
Do.....	8420	.....	Nov. 24	12.0	11.4	.....	6.9	1.75	350
Average.....	.....	.....	.....	13.6	12.9	79.4	9.8	1.41	443

NEW YORK.

<i>Genesee County.</i>									
A. D. Lemley.....	8261	Florimond White Red Top.....	Nov. 17	10.5	10.0	73.9	9.7	1.08	2,500
Do.....	8262	Lane's or French Red Top.....	Nov. 17	15.0	14.3	83.3	18.5	.81	1,210
Do.....	8263	Vilmorin Red Top.....	Nov. 17	12.8	12.2	82.1	14.7	.86	1,485
Average.....	.....	.....	.....	12.8	12.2	79.4	14.3	.92	1,732
<i>Oneida County.</i>									
Henry Branstater.....	7875	Simon Legrand.....	Oct. 15	11.9	11.3	78.2	10.6	1.12	400
Do.....	7876	Florimond Desprez.....	Oct. 15	11.5	10.9	70.3	11.2	1.03	445
Average.....	.....	.....	.....	11.7	11.1	78.8	10.9	1.08	423
<i>Warren County.</i>									
F. H. Crumb.....	8216	Florimond Desprez.....	Nov. 14	15.3	14.5	87.0	17.0	.90	610
Do.....	8217	Klein Wanzlebener.....	Nov. 14	13.8	13.1	81.7	12.8	1.08	675
Average.....	.....	.....	.....	14.6	13.8	84.5	14.9	.99	643
<i>Yates County.</i>									
Robert Platman.....	7964	Dippe's Vilmorin.....	Oct. 24	12.3	11.7	72.4	11.4	1.08	405
Do.....	7965	Florimond Desprez.....	Oct. 24	10.7	10.2	67.7	16.1	1.04	465
Do.....	7966	Simon Legrand.....	Oct. 24	12.9	12.3	75.0	14.3	.90	540
Average.....	.....	.....	.....	12.0	11.4	71.7	13.9	10.1	470

NORTH DAKOTA.

<i>Burleigh County.</i>									
John Yegen.....	7635	.....	Sept. 29	10.9	10.4	70.3	7.8	1.39	453
<i>Cass County.</i>									
J. R. Fuller.....	7647	.....	Oct. 1	13.7	13.0	72.9	4.5	1.62	550
Do.....	7648	Klein Wanzlebener ..	Oct. 1	13.2	12.5	74.2	10.2	1.29	575
M. Woodhull.....	7721	.....	Oct. 6	8.3	7.9	59.2	4.6	1.80	1,102
G. N. Smith.....	8425	Klein Wanzlebener ..	Nov. 15	16.2	15.4	79.0	11.7	1.39	760
Do.....	8426	Dippe's Vilmorin.....	Nov. 15	17.1	16.3	86.8	14.1	1.21	695
Average.....	.....	.....	.....	13.7	13.0	75.5	9.0	1.56	736
<i>Dickey County.</i>									
Charles Stekl.....	7991	Florimond Desprez.....	Oct. 25	10.5	10.0	67.3	6.3	1.66	1,050
Do.....	7992	Klein Wanzlebener ..	Oct. 25	12.7	12.1	73.4	8.8	1.44	1,070
Average.....	.....	.....	.....	11.6	11.0	70.4	7.6	15.5	1,060
<i>Morton County.</i>									
Joseph Miller.....	7764	Brabant.....	Oct. 10	14.5	13.8	73.9	8.1	1.79	508

NORTH DAKOTA—Continued.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Nelson County.</i>									
James Lawer	7683	.....	Oct. 4	<i>P. ct.</i> 14.3	<i>P. ct.</i> 13.6	74.1	9.9	<i>P. ct.</i> 1.45	<i>Gr'ss.</i> 675
<i>Ransom County.</i>									
I. J. Oliver	7612	Klein Wanzlebener ..	Sept. 27	10.9	10.4	70.8	8.1	1.35	805
Do	7613	do	Sept. 27	12.6	12.0	73.7	9.9	1.35	825
Do	7614	Florimond Desprez ..	Sept. 27	9.4	8.9	67.6	7.5	1.26	820
Do	7615	do	Sept. 27	10.6	10.1	73.1	8.8	1.21	725
Average				10.9	10.3	71.3	8.6	1.29	794
<i>Sargent County.</i>									
Henry Straub	8198	Vilmorin	Nov. 11	22.1	21.0	.....	18.3	1.21	220
Do	8199	do	Nov. 11	21.6	20.5	.....	18.4	1.17	215
Average				21.9	20.8	.....	18.4	1.19	218
<i>Stutsman County.</i>									
J. J. Nierling	7792	Klein Wanzlebener ..	Oct. 11	13.2	12.5	77.6	10.5	1.26	570
<i>Traill County.</i>									
G. von Steinwehr ..	7600	.....	Sept. 24	10.5	10.0	69.1	8.1	1.30	1,022
Do	7601	.....	Sept. 24	10.3	9.9	70.1	8.1	1.39	796
P. Herbrandson	7926	Klein Wanzlebener ..	Oct. 20	13.8	13.1	78.4	12.3	1.12	1,263
Bure Bureson	7953	do	Oct. 23	20.6	19.6	84.1	17.0	1.21	397
Wm. Carson	7957	do	Oct. 23	16.7	15.9	73.6	8.8	1.81	288
N. F. Griswold	7958	do	Oct. 23	18.6	17.7	79.1	12.2	1.51	490
C. Cranston	8210	do	Nov. 14	17.8	16.9	82.4	12.5	1.43	650
Average				15.5	14.7	76.7	11.3	1.91	701

OHIO.

<i>Butler County.</i>									
Jno. W. McClellan...	7645	.....	Oct. 1	9.7	9.2	76.4	9.8	0.99	1,017
<i>Erie County.</i>									
B. J. Messig	7797	.....	Oct. 11	9.3	8.8	71.5	8.1	1.15	305
<i>Hamilton County.</i>									
Henry L. Law	8461	.....	Dec. 9	13.1	12.4	80.9	9.4	1.39	458
<i>Sandusky County.</i>									
C. W. Storer	8075	Klein Wanzlebener ..	Oct. 30	12.2	11.6	82.4	10.9	1.12	570
B. B. Overmyer	8408	Simon Legrand	Nov. 24	14.2	13.5	77.2	11.3	1.26	1,210
Do	8409	Klein Wanzlebener ..	Nov. 24	12.3	11.7	71.1	8.9	1.39	1,025
Average				12.9	12.3	76.9	10.3	1.26	935
<i>Trumbull County.</i>									
D. H. Wilder	7894	Vilmorin	Oct. 16	10.1	9.6	69.6	10.1	.99	801
Do	7895	Lane's Improved	Oct. 16	8.0	7.6	77.6	8.9	.90	1,113
Do	7896	do	Oct. 16	11.1	10.6	88.8	13.7	.81	485
Do	7897	Vilmorin	Oct. 16	9.0	8.6	76.9	8.3	1.08	1,273
Do	8280	.....	Nov. 19	9.1	8.7	70.0	7.2	1.26	507
Do	8281	.....	Nov. 19	11.9	11.3	81.0	12.0	.99	1,010
Do	8282	.....	Nov. 19	11.6	11.0	81.1	14.3	.81	371
Average				10.1	9.6	77.9	10.6	9.3	808
<i>Van Wert County.</i>									
Marion Davidson	7889	Silesian	Oct. 16	5.7	5.4	.....	3.4	1.66	320
Do	7890	do	Oct. 16	7.4	7.0	67.3	5.1	1.44	420
Average				6.6	6.2	67.3	4.2	1.55	370

OREGON.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Jackson County.</i>									
F. X. Musty.....	8428	.....	Nov. 28	<i>P. ct.</i> 15.3	<i>P. ct.</i> 14.5	72.2	9.1	<i>P. ct.</i> .68	<i>Grms.</i> 610
Do.....	8429	.....	Nov. 28	16.4	15.6	74.5	17.3	.95	510
Average.....		.....		15.9	15.1	73.4	14.2	.82	560

PENNSYLVANIA.

<i>Dauphin County.</i>									
E. H. Leib.....	8285	Green Top.....	Nov. 19	8.8	8.4	74.6	7.0	1.26	1,014
Do.....	8286	Red Top.....	Nov. 19	8.9	8.4	78.8	9.0	.99	1,404
Average.....		.....		8.9	8.4	76.7	8.0	1.13	1,209
<i>Lancaster County.</i>									
F. M. Weaver.....	7363	Klein Wanzlebener...	Sept. 18	6.8	6.5	63.5	6.6	1.03	1,067
Do.....	7364	Lemaire.....	Sept. 18	6.3	6.0	82.2	5.6	1.12	362
Do.....	7365	Florimond Desprez...	Sept. 18	10.3	9.8	78.0	12.0	.86	380
L. Wingenrath.....	7636	Klein Wanzlebener...	Sept. 29	8.6	8.2	74.1	8.7	.99	537
Do.....	7637	Florimond Desprez...	Sept. 29	9.8	9.3	73.7	9.5	1.03	560
Frank Stauffer.....	7749	Dippe's Vilmorin.....	Oct. 9	6.9	6.6	65.1	8.4	.82	445
Do.....	7750	.....	Oct. 9	6.6	6.3	.....	7.0	.94	610
Average.....		.....		9.3	7.5	72.8	8.3	.97	566
<i>Philadelphia County.</i>									
N. Bart.....	8411	White Sugar.....	Nov. 24	10.9	10.4	75.2	9.0	1.21	1,225

SOUTH DAKOTA.

<i>Brookings County.</i>									
South Dakota Agricultural Experiment Station.	8116	Bulteau Desprez Rich-est.	Nov. 3	15.7	14.9	84.0	14.5	1.08	570
Do.....	8117	Dippe's Vilmorin.....	Nov. 3	15.9	15.1	84.1	18.5	.87	390
Do.....	8118	Oxnard Factory.....	Nov. 3	17.8	16.9	91.3	20.7	.86	328
Do.....	8119	Pajarro Valley, Cal.	Nov. 3	14.4	13.8	76.6	13.3	1.00	418
Do.....	8120	Florimond Desprez...	Nov. 3	13.0	12.4	85.0	7.8	1.67	585
Do.....	8121	Klein Wanzlebener...	Nov. 3	15.2	14.4	86.4	.....	Lost.	556
Do.....	8122	Simon Legrand White Improved.	Nov. 3	14.2	13.5	87.1	.....	Lost.	454
Average.....		.....		15.2	14.4	84.9	14.9	1.10	472
<i>Brown County.</i>									
Andrew Ballweg...	8435	Klein Wanzlebener...	Dec. 1	17.2	16.3	80.4	14.7	1.17	295
<i>Davidson County.</i>									
Salem Bruner.....	7870	.....	Oct. 15	10.7	10.2	66.0	5.9	1.80	821
H. C. Preston.....	8082	.....	Oct. 31	15.8	15.0	78.6	13.1	1.21	790
Average.....		.....		13.3	12.6	72.3	9.5	1.51	806
<i>Grant County.</i>									
D. W. Diggs.....	8043	.....	Oct. 28	11.6	11.0	73.0	7.4	1.57	856
<i>Hyde County.</i>									
Jno. C. Stoner.....	7661	Simon Legrand.....	Oct. 3	13.2	12.5	79.5	13.1	1.01	725
Do.....	7662	do.....	Oct. 3	13.7	13.0	78.7	11.1	1.23	795
Do.....	7961	.....	Oct. 23	14.6	13.9	76.0	14.8	.99	445
Do.....	7962	.....	Oct. 23	13.3	12.6	81.1	11.0	1.21	510
Average.....		.....		13.7	13.0	78.8	12.5	1.11	619

SOUTH DAKOTA—Continued.

Name of grower.	Serial No.	Variety.	When received	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coeff. cent.	Ash.	Average weight of beet.
<i>Kingsbury County.</i>									
W. A. Palmer	7603	Florimond-Desprez.....	Sept. 25	<i>P. ct.</i> 9.0	<i>P. ct.</i> 8.6	68.2	6.9	<i>P. ct.</i> 1.30	<i>Gr'ms.</i> 655
Do	7604	Simon Legrand	Sept. 25	13.0	12.4	73.4	9.0	1.44	450
Average				11.0	10.5	71.1	8.0	1.37	533
<i>McCook County.</i>									
Asael Larson	8049	White Improved	Oct. 29	11.0	10.5	76.4	10.9	1.03	385
Do	8050	do	Oct. 29	11.4	10.8	.....	9.7	1.17	345
Average				11.2	10.6	76.4	10.3	1.10	365
<i>Mead County.</i>									
W. P. Flowers	8412	.....	Nov. 24	14.7	14.0	72.1	8.6	1.71	780
Do	8413	.....	Nov. 24	14.8	14.1	76.3	11.4	1.30	750
Average				14.8	14.1	74.2	10.0	1.51	765

TEXAS.

<i>Scurry County.</i>									
W. M. Sawyer	8024	.....	Oct. 27	9.9	9.4	67.3	6.9	1.44	1,150
Do	8025	.....	Oct. 27	11.0	10.5	71.4	8.2	1.35	995
Average				10.5	10.0	69.3	7.6	1.39	1,072

VIRGINIA.

<i>Augusta County.</i>									
O. K. Lapham	7756	Florimond Desprez Richest.	Oct. 9	10.0	9.5	78.7	13.9	.72	470
Do	7757	Klein Wanzlebener ..	Oct. 9	9.8	9.3	74.2	10.5	.93	576
Do	7758	Lane's Imperial	Oct. 9	8.6	8.2	75.4	9.9	.85	590
Do	7759	Lemaire	Oct. 9	8.9	8.5	71.8	9.9	.90	665
Do	7760	Vilmorin	Oct. 9	8.7	8.3	67.4	9.0	.97	465
Do	7761	do	Oct. 9	6.1	5.8	.....	6.1	1.00	835
Wm. Goodwin	8154	Florimond-Desprez ..	Nov. 7	12.8	12.2	78.0	14.9	.86	228
Do	8155	Klein Wanzlebener ..	Nov. 7	11.1	10.6	69.1	14.4	.77	245
Do	8156	Lane's Improved Im- perial.	Nov. 7	13.3	12.6	84.7	19.6	.68	260
Do	8157	Lemaire Richest	Nov. 7	15.3	14.5	83.2	17.8	.86	170
Do	8158	Vilmorin	Nov. 7	12.1	11.5	80.7	10.8	1.12	255
Do	8159	Vilmorin Improved Imperial.	Nov. 7	16.1	15.3	83.8	20.9	.77	265
J. J. Pennybacker ..	8402	Florimond Desprez ..	Nov. 22	12.6	12.0	.....	7.6	.81	650
Do	8403	Klein Wanzlebener ..	Nov. 22	14.9	14.2	.....	15.2	.63	350
Do	8404	Lane's Improved Im- perial.	Nov. 22	13.3	12.6	.....	16.4	.72	305
Do	8405	Lemaire Richest	Nov. 22	13.6	12.9	73.0	13.3	1.48	228
Do	8406	Dippe's Vilmorin	Nov. 22	14.3	13.6	74.9	10.9	1.48	378
Do	8407	Vilmorin Improved ..	Nov. 22	13.9	13.2	72.9	11.8	1.75	525
Average				12.0	11.4	76.3	12.9	.96	415
<i>Loudoun County.</i>									
J. B. McLaughlin ..	7995	.....	Oct. 25	6.6	6.3	53.7	4.6	1.44	430
Do	7996	.....	Oct. 25	4.8	4.6	.....	3.3	1.44	530
Average				5.7	5.4	53.7	4.0	1.44	480

WASHINGTON.

Name of grower.	Serial No.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beet.
<i>Lewis County.</i>				<i>P. ct.</i>	<i>P. ct.</i>			<i>P. ct.</i>	<i>Gr'ms.</i>
W. J. Hoyne	8436	.....	Dec. 2	16.0	15.2	84.2	14.2	1.12	450

WISCONSIN.

<i>Calumet County.</i>									
Gotfried Abitz	7808	Klein Wanzlebener ..	Oct. 13	9.9	9.4	78.0	8.3	1.20	1,300
Do	7809	Vilmorin Dippe's ..	Oct. 13	13.9	13.2	86.9	18.3	.76	315
Do	7869	Simon Legrand imported.	Oct. 14	13.9	13.2	90.2	17.0	.82	500
Average				12.6	11.9	81.9	14.5	.93	705
<i>Kewaunee County.</i>									
W. Seyk	7701	Dippe's Richest	Oct. 6	15.7	14.9	81.3	14.3	1.10	813
Do	7861	Imported from Bohemia.	Oct. 13	12.6	12.0	77.8	11.5	1.10	450
Average				14.2	13.5	79.6	12.9	1.10	632
<i>Ozaukee County.</i>									
Ernest Barkhausen ..	7943	Lemaire Richest	Oct. 22	11.5	10.9	.....	13.4	.86	420
Do	7944	do	Oct. 22	13.2	12.5	81.5	14.7	.90	590
Average				12.4	11.7	81.5	14.1	.88	505
<i>Vernon County.</i>									
A. J. Rusk	8166	.....	Nov. 7	12.5	11.9	82.3	12.1	1.03	800
Do	8167	.....	Nov. 7	14.8	14.1	80.9	14.4	1.03	420
Do	8168	.....	Nov. 7	16.2	15.4	.....	18.0	.90	260
Average				14.5	13.8	81.6	14.9	.99	493

WYOMING.

<i>Carbon County.</i>									
E. E. Bernard	7390	Vilmorin	Sept. 24	13.3	12.6	73.4	11.9	1.12	1,005
Do	7391	Pink Top	Sept. 24	12.5	11.9	72.2	11.6	1.08	1,420
Average				12.9	12.3	72.8	11.8	1.10	1,213
<i>Crook County.</i>									
H. C. Hensel	7784	.....	Oct. 10	17.1	16.3	.....	12.2	1.40	210
<i>Laramie County.</i>									
Henry S. Parker	8053	.....	Oct. 29	16.7	15.8	84.8	12.4	1.35	690
Do	8054	.....	Oct. 29	19.8	18.8	.....	16.9	1.17	325
Average				18.3	17.3	84.8	14.7	1.26	508

Table showing beets having from 15 to 18 per cent. sucrose.

Name of grower.	Serial No.	State.	County.	Variety.	When received.	Sucrose in juice.	Sucrose in beet.	Purity.	Saline content.	Ash.	Average weight of beets.
						Per ct.	Per ct.			Per ct.	Gr.
University of California.	7619	California.	Los Angeles.	Vilmorin.	Sept. 27	16.8	16.0	87.0	17.9	.94	352
Do.	7616	do	do	Excelsior.	Sept. 27	16.3	15.5	84.5	18.1	.90	407
C. S. Crandall.	8035	Colorado.	Larimer.	Fulteau Desprez.	Oct. 27	16.0	15.2	86.0	16.9	.95	395
Do.	8036	do	do	do	Oct. 27	15.5	14.7	84.7	16.3	.95	460
Do.	8038	do	do	Klein Wanzelebner	Oct. 27	15.9	15.1	86.0	16.7	.95	895
Do.	8039	do	do	do	Oct. 27	16.2	15.4	81.4	18.0	.90	475
H. R. Rhone.	8073	do	Mesa.	Florimond Desprez	Oct. 30	15.2	14.4	86.4	13.0	1.17	433
Pueblo Board of Trade.	8178	do	Pueblo.	Not given	Oct. 8	15.5	14.7	82.9	13.3	1.17	650
Do.	8179	do	do	do	Nov. 8	15.9	15.1	84.1	14.0	1.12	580
Do.	8180	do	do	do	Nov. 8	15.4	14.6	83.7	14.3	1.08	485
C. W. Zepp.	8065	do	Yuma.	do	Nov. 8	15.7	14.9	79.7	12.1	1.30	333
E. McAllister.	8266	Illinois.	Will.	Simon Legrand	Oct. 29	15.9	15.1	85.0	16.1	.99	600
F. H. Crumb.	8216	do	Warren.	French Richest	Nov. 17	15.3	14.5	87.0	17.0	.90	610
A. A. Fellers.	7775	Iowa.	Black Hawk.	Florimond Desprez	Nov. 14	15.9	15.1	81.5	18.1	.88	625
R. Hoff.	7892	do	Webster.	Klein Wanzelebner	Oct. 10	15.9	15.1	95.2	18.3	.81	320
Do.	8173	do	do	Vilmorin	Oct. 16	15.9	15.1	95.2	18.3	.81	320
Angust Bohme	8021	do	do	do	Nov. 8	17.6	16.7	91.1	25.9	.68	520
G. B. Lord	8021	do	Carroll.	do	Oct. 27	15.5	14.7	85.2	14.4	1.08	213
A. L. Bandy.	7811	Kansas.	Johnson.	Vilmorin	Oct. 13	16.8	16.0	82.2	12.2	1.38	180
O. Coyle.	8433	do	Hamilton.	Klein Wanzelebner	Oct. 28	15.7	14.9	82.2	13.8	1.12	720
Maryland Agricultural Experiment Station.	8057	Maryland.	Barber.	Not given	Dec. 1	17.8	16.9	84.8	17.3	1.03	140
Do.	8200	do	Prince George.	Dippe's Vilmorin	Oct. 29	15.9	15.1	90.4	19.6	.81	383
Do.	8200	do	do	do	Nov. 12	15.4	14.6	83.0	26.1	.59	170
Do.	8229	do	do	do	Nov. 15	15.1	14.4	83.0	13.9	.95	385
Do.	8249	do	do	do	Nov. 13	15.1	14.6	82.8	24.4	.63	335
Do.	8254	do	do	do	Nov. 15	15.1	14.4	86.3	19.6	.77	235
Do.	8443	do	do	do	Nov. 15	17.6	16.7	91.2	19.6	.90	213
Do.	8444	do	do	Simon Legrand	Dec. 4	17.8	16.9	84.8	19.8	.90	163
Do.	8446	do	do	Fulteau Desprez Richest	Dec. 4	17.4	16.5	82.8	17.6	.99	125
W. H. Tunney & Co.	8139	Massachusetts.	Suffolk.	Klein Wanzelebner	Dec. 4	16.8	16.0	82.8	17.0	.99	350
J. R. Devenport.	8284	Michigan.	Mustegon.	Not given	Nov. 5	16.4	15.6	89.1	17.2	.95	385
Dr. E. J. Howe.	7696	do	Ionia.	Russian.	Nov. 19	16.4	15.6	89.1	17.2	.95	385
J. S. Lawson	8047	do	Macomb.	Lemaitre	Oct. 6	17.7	16.8	84.7	21.6	.82	337
Do.	8048	do	do	Simon Legrand.	Oct. 29	16.8	16.0	89.8	28.5	.59	680
Robert Glover	7606	do	Wilkin.	Klein Wanzelebner	Oct. 29	15.5	14.7	85.2	18.0	.86	705
John Hunter	7659	Minnesota.	Anoka.	Simon Legrand.	Oct. 29	15.4	14.6	80.6	15.6	.99	447
Do.	7707	do	do	Not given	Sept. 24	15.4	14.6	80.6	15.6	.99	447
Leonhard Ziermann.	7753	do	do	do	Oct. 2	15.9	15.1	84.1	17.2	.93	680
E. A. Donnell	7788	do	Carver.	Klein Wanzelebner	Oct. 6	16.3	15.5	82.3	18.3	.89	387
W. H. Buld.	7877	do	Goodhue.	do	Oct. 9	15.8	15.0	81.0	15.2	1.04	503
Peter Weinand	8151	do	Martin.	do	Oct. 11	16.9	16.1	86.7	18.2	.93	447
W. H. Laverie.	8171	do	Hennepin.	do	Oct. 15	15.0	14.2	85.2	13.9	1.03	750
Simon Huntington.	8007	do	do	Not given	Nov. 6	16.5	15.7	79.2	15.3	1.08	847
Do.	8007	do	do	Klein Wanzelebner.	Nov. 8	15.6	14.8	87.2	13.8	1.99	600
Do.	8007	do	Cottonwood.	Florimond Desprez.	Oct. 27	15.6	14.8	72.9	10.8	1.44	615

Table showing beets having from 15 to 18 per cent. sucrose—Continued.

Name of grower.	Serial No.	State.	County.	Variety.	When received.	Sucrose in juice, in beet.	Purity.	Saline coefficient.	Ash.	Average weight of beets.
James Taylor	8218	Minnesota	Murray	Not given	Nov. 14	Per ct. 17.1	Per ct. 16.3	17.3	Per ct. .99	Gr. 475
H. C. Bartlett	8103	do	Travers	Simon Legrand	Nov. 3	17.5	16.6	84.7	1.21	575
H. W. Koch	8110	do	Dakota	German sugar	Nov. 3	16.7	15.9	83.4	1.17	400
A. De Sutter	8127	do	Lyon	Not given	Nov. 4	17.6	16.7	84.8	1.53	480
Hans Jagers	8062	do	Becker	do	Oct. 30	16.0	14.3	77.3	1.26	1,060
E. Johnson	7932	do	Chicago	Florimond Desprez	Sept. 29	13.1	14.4	73.5	1.08	495
Gus. Olson	7982	Nbraska	Kearney	Klein Wanzelebener	Oct. 2	13.6	14.8	76.1	1.17	214
J. D. Evans	7656	do	Hamilton	Not given	Oct. 2	15.1	14.4	83.1	1.15	210
A. H. Gale	8211	do	Rock	Klein Wanzelebener	Nov. 14	15.2	14.4	83.1	1.26	400
J. B. Olson	8219	do	Phelps	Klein Wanzelebener	Nov. 14	16.0	15.2	75.8	1.53	290
M. O'Connor	7738	do	Garfield	Vilmorin	Oct. 8	17.6	16.7	83.4	1.28	860
J. Gabriel	8128	do	Saunders	Not given	Nov. 4	17.7	16.8	17.2	1.03	305
Do	8129	do	do	do	Nov. 4	15.3	14.5	83.2	1.03	370
C. H. Purinton	7915	do	Perkins	Klein Wanzelebener	Oct. 18	16.5	15.7	79.3	1.30	955
H. S. Morton	7640	do	Knox	Not given	Sept. 29	15.3	14.5	81.4	1.17	595
Henry Smith	8417	do	York	Not given	Nov. 24	16.4	15.6	78.5	1.48	445
Do	8418	do	do	do	Nov. 24	15.4	14.6	9.5	1.62	210
J. B. Martin	8010	do	Colfax	Vilmorin	Oct. 27	15.4	14.6	81.9	1.08	523
Hans Stott	7891	do	Hall	Not given	Oct. 16	16.4	15.6	90.6	1.21	448
Fred. Stuehlsen	7893	do	do	German white	Oct. 16	17.5	16.6	87.1	1.21	398
H. H. Taylor	8045	do	Hitchcock	Lemaire	Oct. 28	17.7	16.8	76.3	1.57	413
Do	8046	do	do	Desprez	Oct. 28	17.5	16.6	76.1	1.53	350
H. H. Saunders	7865	do	Holt	Not given	Oct. 14	16.1	15.3	79.9	1.43	670
W. B. Lower	8002	do	do	Imported white	Oct. 25	15.1	14.4	81.6	1.03	335
C. C. Ward	8453	do	Thayer	Klein Wanzelebener	Dec. 6	16.9	16.1	77.9	1.39	282
Do	8455	do	do	Desprez	Dec. 6	17.1	16.2	83.2	1.26	395
Do	8456	do	do	Klein Wanzelebener	Dec. 6	15.9	15.1	76.4	1.62	500
T. E. Tackley	7938	do	Pawnee	Klein Wanzelebener	Dec. 21	15.6	14.8	83.4	1.08	432
C. A. Ready	7817	do	Hayas	Not given	Oct. 13	17.3	16.4	79.7	1.39	590
G. L. Sherman	7660	do	Frontier	Desprez	Oct. 25	17.1	16.3	85.9	1.04	490
W. F. Sherman	7993	do	do	Vilmorin improved	Oct. 31	15.7	14.9	81.3	1.30	350
A. Richardson	8085	do	Sheridan	Not given	Oct. 31	15.8	15.0	10.6	1.53	340
C. Osterman	8124	do	Dodge	Klein Wanzelebener	Nov. 4	16.3	15.5	83.2	1.03	450
R. P. Gregg	7975	do	Dawes	do	Oct. 11	16.2	15.4	72.7	1.03	290
E. W. Tracy	7801	do	Box Butte	do	Sept. 22	15.0	14.3	68.5	1.0	507
F. H. Trowbridge	7366	do	Antelope	Not given	Sept. 22	16.1	15.3	82.1	.95	241
Do	7367	do	do	do	Sept. 22	16.9	15.0	81.5	1.03	176
Do	7368	do	do	do	Sept. 22	16.6	15.8	88.8	1.03	176
C. A. Hathaway	7675	do	do	Klein Wanzelebener	Oct. 4	16.0	15.3	86.4	1.8	265
W. H. Cormeny	7998	do	do	Florimond Desprez	Oct. 25	16.5	15.7	16.7	.99	380
E. Adams	8109	do	do	Vilmorin	Nov. 3	16.7	15.9	90.7	1.67	400
J. W. White	8000	do	Lincoln	do	Oct. 25	15.8	15.0	86.8	.90	930
A. D. Lemly	8262	New York	Genesee	Lane's or French	Nov. 17	15.0	14.3	83.3	.81	1,210

Wm. Carson	7957	North Dakota	Traill	Not given	Oct. 23	16.7	15.9	73.6	8.8	1.81	288
C. Cranston	8210	do	do	Not given	Nov. 14	17.8	16.9	82.4	12.5	1.43	650
G. N. Smith	8425	do	Cass	Klein Wanzenbener	Nov. 15	16.2	15.4	79.0	11.7	1.39	760
Do	8426	do	do	Klein Wanzenbener	Nov. 15	17.1	16.3	86.8	14.1	1.21	690
F. X. Musty	8428	Oregon	Jackson	Dippe's Vilmorin	Nov. 28	15.3	14.5	72.2	9.1	.68	610
Do	8429	do	do	Not given	Nov. 28	16.4	15.6	74.5	17.3	.95	510
H. C. Preston	8082	South Dakota	Davidson	do	Oct. 31	15.8	15.0	78.6	13.1	1.21	790
South Dakota Agricultural Experimental Station	8116	do	Brookings	Bultean Desprez Richest	Nov. 3	15.7	14.9	84.0	14.5	1.06	570
Do	8117	do	do	Dippe's Vilmorin	Nov. 3	15.9	15.1	84.1	18.5	.87	390
Do	8118	do	do	Oxnard Factory	Nov. 3	17.8	16.9	91.3	20.7	.86	328
Do	8121	do	do	Klein Wanzenbener	Nov. 3	15.2	14.4	86.4	-----	-----	556
A. Ballweg	8435	do	Brown	do	Dec. 1	17.2	16.3	80.4	14.7	1.17	295
Wm. Goodwin	8157	Virginia	Augusta	Lemaire Richest	Nov. 7	15.3	14.5	83.2	17.8	.86	170
Do	8159	do	do	Vilmorin Improved	Nov. 7	16.1	15.3	83.8	20.9	.77	265
W. J. Hoyme	8436	Washington	Louise	Not given	Dec. 2	16.0	15.2	84.2	14.2	1.12	450
W. S. K.	7701	Wisconsin	Kewaunee	Vilmorin Richest	Oct. 6	15.7	14.9	81.3	14.3	1.10	813
A. J. Rusk	8168	do	Vernon	Dippe's Richest	Nov. 7	16.2	15.4	81.3	18.0	.90	260
H. C. Hensel	7784	Wyoming	Crook	Not given	Oct. 10	17.1	16.3	-----	12.2	1.40	210
Henry S. Parker	8053	do	Laramie	do	Oct. 29	16.7	15.8	84.8	12.4	1.35	690

Table showing beetles having 18 per cent. sucrose and over.

C. W. Zepp	8113	Colorado	Yuma	Klein Wanzenbener	Nov. 3	19.2	18.2	-----	13.3	1.44	93
John Betts	8273	Indiana	Clinton	Not given	Nov. 17	19.1	18.2	78.9	14.7	1.30	410
R. Hoff	8172	Iowa	Webster	Vilmorin	Nov. 8	18.1	17.2	87.5	23.5	.77	220
Maryland Agricultural Experimental Station	8438	Maryland	Prince Georges	do	Dec. 4	22.0	21.0	-----	34.9	.63	90
Do	8439	do	do	Bultean Desprez	Dec. 4	18.4	17.5	-----	23.9	.77	40
Do	8440	do	do	Flornond Desprez	Dec. 4	20.0	19.0	-----	27.8	.72	58
Do	8441	do	do	Klein Wanzenbener	Dec. 4	19.8	18.8	-----	22.0	.90	63
Do	8442	do	do	Vilmorin	Dec. 4	19.9	18.9	94.8	20.9	.95	375
W. H. Maxwell	8208	Minnesota	Murray	Klein Wanzenbener	Nov. 14	18.6	17.7	84.3	19.6	.95	279
James Taylor	8102	do	do	do	Nov. 14	18.7	17.8	82.4	18.2	1.03	240
H. C. Bartlett	8268	Nebraska	Travers	German Legrand	Nov. 17	18.3	17.4	79.2	14.1	1.20	840
F. H. Knowles	7369	do	Lincoln	Klein Wanzenbener	Nov. 17	19.8	18.8	82.8	14.7	1.03	515
F. H. Trowbridge	8084	do	Antelope	Not given	Sept. 22	18.8	17.9	81.8	18.3	1.35	119
T. A. Fleming	7710	do	Sherridan	do	Oct. 31	19.6	18.6	78.7	12.5	1.57	500
E. H. Benedict	7711	do	Holt	Klein Wanzenbener	Oct. 6	18.8	18.8	-----	12.7	1.36	205
Do	7711	do	do	do	Oct. 6	18.1	17.2	-----	10.7	1.69	187
Edgar Bruner	8197	do	do	Not given	Nov. 11	20.4	19.4	73.9	10.8	1.59	220
C. E. Ward	8454	do	Thayer	Lemaire	Dec. 6	18.3	17.3	82.1	13.6	1.35	385
Do	8456	do	do	Klein Wanzenbener	Dec. 6	18.2	17.4	84.7	16.9	1.08	323
William Gausser	8138	do	Scott Bluff	Not given	Nov. 5	23.9	22.7	83.3	15.6	1.50	333
C. D. Emerson	8447	do	Kearney	Lemaire Richest	Dec. 4	22.8	21.7	-----	13.7	1.66	155
Do	8448	do	do	Klein Wanzenbener	Dec. 4	25.5	24.2	-----	14.6	1.75	303
G. W. Hultz	8028	do	Deuel	do	Oct. 27	19.8	18.8	-----	12.2	1.62	248
Dan Nef	7973	do	Perkins	do	Oct. 24	18.0	17.1	90.5	15.4	1.17	630

Table showing beets having 18 per cent. sucrose and over—Continued.

Name of grower.	Serial No.	State.	County.	Variety.	When received.	Sucrose in juice.		Purity.	Saline coefficient.	Ash.	Average weight of beets.
						Per ct.	Per ct.			Per ct.	Gr.
Bure Bureson	7953	North Dakota.	Traill.	Klein Wanzlebener.	Oct. 23	20.6	19.6	84.1	17.0	1.21	397
N. V. Griswold.	7958	do	do	do	Oct. 23	18.6	17.7	79.1	12.2	1.51	490
Henry Straub.	8198	do	Sargent.	Vilmorin.	Nov. 11	22.1	21.0	84.3	18.3	1.21	220
Do	8199	do	do	do	Nov. 11	22.1	20.5	84.3	18.4	1.17	215
Henry S. Parker	8054	Wyoming.	Laramie.	Not given.	Oct. 29	19.8	18.8	84.3	16.9	1.17	325

Table showing yield of beets of different weights per acre, etc.

Weight of beet.		Available sugar per acre in pounds.									
Grammes.	Ounces.	Yield per acre.	8 per cent.	9 per cent.	10 per cent.	11 per cent.	12 per cent.	13 per cent.	14 per cent.	15 per cent.	16 per cent.
		Tons.									
100	3.53	4.40	563	634	704	774	845	915	986	1,056	1,126
100	3.53	4.40	1,126	1,267	1,408	1,549	1,690	1,830	1,971	2,112	2,253
200	7.06	8.80	1,680	1,901	2,112	2,323	2,534	2,746	2,957	3,168	3,379
300	10.59	13.20	2,233	2,534	2,835	3,136	3,437	3,738	4,039	4,340	4,641
400	14.12	17.60	2,816	3,168	3,520	3,872	4,224	4,576	4,928	5,280	5,632
500	17.65	22.00	3,379	3,802	4,224	4,646	5,068	5,491	5,914	6,336	6,758
600	21.18	26.40	3,942	4,435	4,928	5,421	5,914	6,406	6,899	7,392	7,885
700	24.71	30.80	4,505	5,069	5,632	6,195	6,758	7,322	7,885	8,448	9,011
800	28.24	35.20	5,069	5,702	6,336	6,970	7,603	8,237	8,870	9,504	10,138
900	31.77	39.60	5,632	6,336	7,040	7,744	8,448	9,152	9,856	10,560	11,264
1,000	35.30	44.00	6,195	7,040	7,885	8,730	9,575	10,420	11,265	12,110	12,955
1,100	38.83	48.40	6,758	7,885	8,730	9,575	10,420	11,265	12,110	12,955	13,800
1,200	42.36	52.80	7,322	8,448	9,293	10,138	10,983	11,828	12,673	13,518	14,363
1,300	45.89	57.20	7,885	9,011	9,856	10,701	11,546	12,391	13,236	14,081	14,926
1,400	49.42	61.60	8,448	9,575	10,420	11,265	12,110	12,955	13,800	14,645	15,490
1,500	52.95	66.00	9,011	10,138	11,083	12,028	12,973	13,918	14,863	15,808	16,753

EXPLANATORY NOTE.—To get the yield of beets per acre of any given weight, follow the line of the given weight to the right to column of yield in tons. The columns of figures under the several per cents of sugar in the beets give roughly the quantity of sugar which would be obtained per acre, with the yield and richness indicated. To get the total sugar per acre, multiply the per cent in each case by 2,000, and by the yield per acre in tons. Thus the total sugar produced per acre for a beet having 14 per cent of sugar and having a weight of 600 grammes would be $14 \times 2,000 \times 26.4 = 7,392$ pounds.

The yield in tons is based on the supposition that 40,000 plants grow upon each acre. This rule could be applied to beets up to 700 grammes in weight, but above that the number of beets per acre would not reach so high a figure. The yields, therefore, for beets over 100 grammes are exaggerated. It was thought best, however, to complete the table on the one plan.

The available sugar is given approximately at 80 per cent of the total sugar. The actual amount of sugar obtained in any instance might vary largely from the number, but 80 per cent may be taken as a fair average yield.

In the preceding summary of the beets sent from Nebraska are not included those which were examined at the Grand Island Sugar Factory under the direction of the Chemical Division, but only those which were sent directly to the Department at Washington for examination. In addition to these two sets of analyses large numbers of samples were examined in the laboratory of the Agricultural Experiment Station at Lincoln.

The following table contains the results of the analyses made by Mr. H. E. L. Horton at Grand Island, Nebr., on samples of beets delivered for manufacture:

Name.	Post-office address.	No. of samples.	Average weight of beet.	Total solids indicated by Brix spindle.	Sucrose in juice.	Purity coefficient.
			<i>Grams.</i>	<i>Pr. ct.</i>	<i>Pr. ct.</i>	
Allen, E. M.	Schnyler, Colfax Co.	2	285	20.0	16.8	84.0
Anderson, E. C.	Dannebrog, Howard Co.	1	204	20.3	17.1	84.2
Anton, Conrad	Palmer, Merrick Co.	3	130	18.6	16.0	86.7
Appel, Christ	Dannebrog, Howard Co.	1	189	20.1	17.9	89.1
Asterhold, W.	Grand Island	9	251	20.2	16.5	83.2
Aye, Peter	do	4	204	19.7	16.4	82.8
Do	do	2	273	20.6	17.5	84.9
Barnard, Alfred	Alda, Hall Co.	1	419	20.5	16.5	80.5
Barick, William	do	3	131	20.0	16.6	83.0
Barth, Fritz	Grand Island	12	173	19.3	16.3	84.0
Baummann, Eno	do	3	221	20.2	16.9	83.8
Baumann, Remmet.	do	2	209	19.5	16.5	82.5
Backkova, Fr.	St. Michael, Buffalo Co.	1	191	19.1	16.3	85.3
Bame, E.	Schnyler, Colfax Co.	1	242	19.6	16.7	85.2
Beckmann, A.	Grand Island	1	351	19.0	15.2	80.0
Becker, Fritz	do	1	232	23.5	20.1	85.5
Do	do	1	124	19.9	16.7	83.9
Berry, George	Seward, Seward Co.	2	280	19.7	16.7	84.8
Bern, Friedrich	Grand Island	9	255	19.5	16.3	83.0
Bemis, A. H.	Seward, Seward Co.	3	334	18.1	14.9	82.4
Beberniss, John	Grand Island	12	294	19.3	16.0	82.6
Bell, D. E.	Chapman, Merrick Co.	3	231	20.0	16.7	83.4
Beberniss, Fritz	Grand Island	15	212	20.5	17.3	84.4
Belville, Joseph	Chapman, Merrick Co.	7	203	18.6	15.8	85.0
Beyer, Karl	Grand Island	10	273	18.7	15.9	84.2
Blaine, H. M.	do	1	209	19.8	17.1	86.9
Blunk, Ad.	do	15	218	20.1	17.4	86.9
Bowman, S. S.	Wood River, Hall Co.	1	188	21.0	16.4	78.1
Boose, Johann	Grand Island	12	188	18.5	15.6	82.7
Boekholm, Carl	Cairo, Hall Co.	7	182	19.6	16.3	81.4
Boersen, Henry	Grand Island	12				
Bruckner, R. J.	Nantasket, Buffalo Co.	1	267	20.5	17.7	86.3
Brannan, F.	Central City, Merrick Co.	1	217	22.1	17.9	81.6
Brachmann, D.	St. Libory, Howard Co.	1	275	18.2	14.4	79.8
Brandt, David	Abbott, Hall Co.	4	245	20.4	17.4	87.0
Braasch, Adolph.	Grand Island	8	213	19.2	15.6	81.2
Bruckmann, E.	do	5	302	18.9	15.5	82.8
Buckow, Fritz	do	1	542	19.5	16.5	84.6
Bullock, J. A.	Alda, Hall Co.	1	178	18.4	16.1	87.4
Burman, Oscar	Boelus, Howard Co.	1	215	21.2	17.9	84.4
Buhmann, Hury	St. Libory, Howard Co.	1		19.3	16.7	
Buell, H. G.	Chapman, Merrick Co.	5	199	18.8	15.5	82.4
Buchholz, Fr.	Grand Island	9	178	18.2	15.3	81.6
Buhke, John	do	5	287	19.1	16.0	83.8
Busing, Ernst	do	2	229	18.9	15.8	85.6
Case, C.	Clarks, Merrick Co.	1	334	20.0	15.5	77.5
Carr, Geo. W.	St. Michael, Buffalo Co.	1	160	18.2	15.1	82.9
Carter, Fr. M.	St. Paul, Howard Co.	1		22.7	18.2	
Carlsen, N. T.	Dannebrog, Howard Co.	1			16.6	
Campbell, J. M.	Cairo, Hall Co.	2	240	20.0	15.9	79.2
Clad, Jno. E. R.	Chapman, Merrick Co.	1	322	22.8	18.8	82.5
Class, Frank	Ravenna, Buffalo Co.	1	160	20.5	16.4	80.0
Clarks Sugar and Beet Co.	Clarks, Merrick Co.	1	187	23.2	19.1	82.3
Claussen, Turgen	Grand Island	7	282	20.6	17.3	84.0
Cranviseur, John	Columbus, Platte Co.	1	270	21.5	18.4	85.6
Craig, C., E. and A. R.	do	8	279	18.8	15.5	82.4
Cushman, I. B.	Chapman, Merrick Co.	13	269	18.8	15.6	83.0
Cunningham, M. J.	Wood River, Hall Co.	6	230	19.3	16.4	84.8
Daniels, A. P.	Clarks, Merrick Co.	1	207	19.8	16.6	78.2

Name.	Post-office address.	No. of samples.	Average weight of beet.	Total solids indicated by Brix spindle.	Sucrose in juice.	Purity coefficient.
			<i>Grams.</i>	<i>Pr. ct.</i>	<i>Pr. ct.</i>	
Dankert, Hans	Grand Island	1	335	18.4	15.4	83.7
Damman, Claus	do	1	217	19.7	17.3	87.8
David, M. F.	Broken Bow, Custer Co.	1	339	22.1	17.6	79.6
Daberkon, Karl	Grand Island	4	173	18.8	15.9	86.0
De Moss, W. T.	Shelton, Hall Co	1	164	23.4	21.0	89.3
Detlef, S.	Grand Island	8	138	20.2	16.7	81.9
Detlef, Cristen	do	4	265	18.9	15.5	81.9
Deichmann, Carl	do	22	306	19.4	16.4	84.5
Diehl, E.	Cairo, Hall Co	1	146	20.5	16.8	81.9
Diekmann, Peter	St. Libory, Howard Co	4	277	19.4	16.6	86.7
Dorgensen, Søren	Dannebrog, Howard Co	1	228	19.5	16.2	83.1
Dohms, Carl	Grand Island	9	178	18.7	15.4	82.4
Dobrinke, Aug	do	3	332	20.6	17.5	84.6
Drake, Leroy	Shelton, Buffalo Co	1		19.3	17.0	88.1
Dutton, Jas. H.	Chapman, Merrick Co	2	198	20.9	17.6	83.8
Dünemann, C. H.	Grand Island	18	251	20.4	17.3	85.1
Dunermann, G	do	12	197	19.3	15.8	84.0
Eickhoff, H.	do	4	219	19.7	16.1	82.7
Elstermeur, Carl	do	1	173	22.3	18.2	81.7
Ennis, Martin	do	1	271	17.7	15.0	84.7
Enders, Casper	St. Libory, Howard Co	2		20.3	16.6	81.6
Erozim, Chas	Ravenna, Buffalo Co	1		23.0	18.5	80.5
Erickson, Jacob	Nysted, Howard Co	1		18.2	14.6	80.2
Erickson, Nels.	do	1	390	20.7	17.4	84.1
Ernstmeyer, F.	Grand Island	5	224	19.6	15.6	80.1
Erozim, Anton	Ravenna, Buffalo Co	2		19.6	15.9	85.4
Ewoldt, Cay	Grand Island	1	409	15.3	11.9	77.7
Ewold, B.	do	11	259	17.3	14.1	81.5
Ewold, Claus	do	2	443	18.2	14.5	80.0
Ewing, John	Wood River, Hall Co	4	180	19.0	16.5	83.4
Falldorf, Fred	Grand Island	11	206	18.6	15.5	82.1
Falles, W. H.	do	2	125	20.7	17.8	85.3
Fay, Peter	St. Libory, Howard Co	1	212	18.3	15.4	84.1
Farnham, D. W.	Central City, Merrick Co	1	98	19.9	16.7	83.9
Fisher, John	Ravenna, Buffalo Co	1	232	19.8	16.1	81.3
Fishburn, W. H.	Grand Island	8		19.8	15.8	79.3
Fischer, Jul.	do	6	234	20.1	17.7	89.9
Flörke, Heinz	do	7	275	19.7	16.4	83.5
Folson, James	do	5	211	19.4	16.1	83.0
Foulk, Geo.	St. Paul, Howard Co					
Frauen, Jos.	St. Libory, Howard Co	1	234	20.0	17.1	85.5
Frey, J. S.	Boelus, Howard Co	1	193	20.0	16.7	83.5
Frauen, Paul	Lockwood, Merrick Co	10	331	19.1	16.1	83.7
Franz, Fred	Alda, Hall Co	3		20.0	17.0	87.6
Friend, John	Grand Island	4	191	19.9	16.8	84.5
Frank, Jacob	do	11	271	20.0	16.6	84.0
Gallup, Henry A.	Alda, Hall Co	5	131	19.0	15.7	82.6
Gatwerth, Erbs	Duncan, Platte Co	1	212	18.7	15.9	84.4
Gallup, Henry A.	Alda, Hall Co	1	163	19.5	16.1	82.5
Gehrt, Peter	Nantasket, Buffalo Co	1	210	18.3	15.5	84.7
Gerard, A.	Bellwood, Butler Co	1	270	21.5	18.4	85.6
Geisinger, Felix	Grand Island	10	263	19.6	15.3	81.6
Giese, Henry	do	6		17.8	18.0	82.0
Glaggner, Paul	do	4	240	20.9	17.8	85.2
Gottschalk, Fritz	Fremont, Dodge Co	1	414	17.5	13.4	76.4
Goehring, Rich	Grand Island	14	218	19.5	16.9	85.1
Goehring, Richard	do	3	151	19.6	16.2	87.3
Goetsche, Christ.	do	4	119	21.5	18.2	83.9
Gosda, Herman	do	2	204	18.4	15.6	84.7
Grant, Jas.	St. Libory, Howard Co	1	303	18.2	14.6	80.2
Grotzky, Claus	Merrick Co	5	179	18.5	15.3	82.1
Grozch, Julius	Grand Island, Hall Co	6	180	19.3	16.0	83.2
Grembe, Jacob	do	4		17.2	15.1	87.2
Grotzky, Claus	do	2	144	20.3	17.6	86.8
Grumpecht, Carl	Shelton, Buffalo Co	1	142	18.5	14.1	76.2
Gutzow, Henry	Grand Island	1		21.0	19.9	
Grünther Bros.	Ravenna, Buffalo Co	1	255	18.7	15.2	81.2
Haldemann, J. T.	Alda, Hall Co	1	78	19.8	16.6	83.9
Hannibal, P. M.	Dannebrog, Howard Co	1	211	19.2	16.3	84.9
Ham, Henry	Grand Island	1	236	16.8	12.6	75.0
Hansen, Peter	Dannebrog, Howard Co	1	221	17.1	11.8	69.0
Hamilton, T. M.	Warner's Addition	5	194	17.9	14.5	81.0
Hand, John	Seward, Seward Co	2	294	18.9	16.5	81.6
Harris, T. R.	Marquette, Hamilton Co	1	188	20.3	16.7	83.1
Ham, Moses	St. Michael, Buffalo Co	1	215	18.3	14.2	72.1
Hamilton, T. M.	Grand Island	24	410	18.9	15.9	84.1
Hansen, Gils	do	11	257	19.9	16.7	84.1
Halling, Wm.	Merrick Co	16	239	19.2	16.0	82.7
Hansen, Jens	Dannebrog, Howard Co	2	254	18.7	15.8	84.7

Name.	Post-office address.	No. of sam- ples.	Aver- age weight of beet.	Total solids indica- ted by Brix spindle.	Sucrose in juice.	Purity coeffi- cient.
			Grams.	Pr. ct.	Pr. ct.	
Haun, Y. C.	Grand Island	10	21.5	18.4	87.6	
Hamlin, J. J.	Seward, Seward Co.	2	151	19.2	15.7	81.7
Hansjosten, Peter	Chapman, Merrick Co.	6	278	19.4	16.2	83.5
Hansen, Jens	Boelus, Howard Co.	5	285	20.3	16.9	83.2
Hansjosten, Jahn	Grand Island	21	245	19.4	15.6	81.9
Hasman, Ernst and Fritz	do	25	241	19.2	16.4	84.6
Henrikson, M.	Dannebrog, Howard Co.	1	246	20.0	16.2	82.4
Henrikson, L. H.	Boelus, Howard Co.	1	343	18.8	15.5	81.9
Hermansen, Martin	Dannebrog, Howard Co.	1	236	20.6	17.5	86.6
Hegeman, O. R.	Buckley, Jefferson Co.	1	135	20.9	18.1	84.3
Hensel, Wm	Shelton, Buffalo Co.	1	232	21.0	17.7	84.3
Hume, Heim	Grand Island	8	178	18.7	11.7	78.6
Hessel, Joseph	do	8	227	20.0	15.9	82.0
Hein, Claus	Fremont, Dodge Co.	2	227	20.5	17.5	85.4
Hein, Mathias	Chapman, Merrick Co.	2	192	22.4	18.9	84.3
Heinz, Nich	Pleasant Add., Hall Co.	8	266	19.1	16.4	85.9
Helkrey, Jay	Norfolk, Madison Co.	3	488	19.0	15.8	83.2
Hillis, Jno. & W	Doniphan, Hall Co.	3	317	19.5	15.8	82.8
Horak, John	Sherman Co.	1	292	20.0	16.3	81.5
Houseworth, More	Fremont, Dodge Co.	1	324	20.1	17.2	85.6
Houten, J. D. van	Norman, Kearney Co.	1	204	21.5	19.4	90.2
Hohman, Caspar	Grand Island	9	134	19.6	16.0	81.6
Honey, well, G. W	St. Paul, Howard Co.	2	310	21.0	18.5	88.3
Hunter, C. H.	Seward, Seward Co.	1	130	20.6	17.4	84.5
Hund, G. & B.	Cairo, Hall Co.	3	260	19.5	15.6	82.1
Husch, Peter	Grand Island	9	212	19.7	16.8	85.3
Janssen, Peter	Rockville, Sherman Co.	1	101	19.6	16.9	86.2
Jacob, Georg	St. Paul, Howard Co.	2	396	19.2	15.5	80.0
Jensen, Christ	Dannebrog, Howard Co.	1	324	16.8	14.2	84.5
Karp, Chas	St. Michael, Buffalo Co.	1	143	20.6	17.3	83.9
Karstel, George	St. Libory, Howard Co.	1	286	21.2	18.3	86.3
Kettler, A. B.	do	2	321	18.9	16.3	86.4
Kent, M.	Grand Island	1	219	20.6	18.1	87.8
Kühn, H. F. W.	Dannebrog, Howard Co.	1	277	20.2	16.0	79.2
Ketteler, A. H.	St. Libory, Howard Co.	2	289	19.8	16.3	82.5
Kunyon, Ch.	Boelus, Howard Co.	1	270	20.8	17.2	82.7
Keinch, M. E.	Cairo, Hall Co.	1	211	20.0	17.1	80.5
Kingsley, O. H.	Clarks, Merrick Co.	3	164	20.7	16.3	83.2
Klase, Rob.	Doniphan, Hall Co.	1	354	16.1	14.1	77.8
Kleine, E.	Grand Island	1	206	19.0	14.8	80.7
Klein, Ernst	do	1	218	16.7	15.0	83.7
Klingenberg, Hans	Chapman, Merrick Co.	2	339	18.5	15.5	79.6
Klunker, Fred	Shelton, Buffalo Co.	2	360	19.7	15.9	82.3
Knippfals, Chr	Grand Island	8	221	19.7	15.8	84.4
Kosch, Vincent	Boelus, Howard Co.	1	215	21.2	17.9	84.0
Kolar, Joseph	Ravenna, Buffalo Co.	1	181	20.0	16.8	82.5
Kozel, Anton	Ravenna, Buffalo Co.	2	373	21.2	17.5	87.1
Köhler, Oscar	Grand Island	11	240	20.2	17.6	83.2
Kroeger, Hans	do	1	169	20.8	17.3	82.7
Kroeger, Rud	do	4	219	20.4	17.2	83.4
Kruse, Henry	do	15	252	19.1	16.0	81.4
Kraemer, Peter	Merrick Co.	25	276	18.4	15.0	85.8
Krekuke, Jul	Alda, Hall Co.	4	277	19.9	16.6	81.8
Kroeger, Fred	Grand Island	9	286	19.2	15.7	85.4
Kroeger, Michael	do	21	283	20.6	18.8	79.1
Kuhlman, W. M.	do	1	186	19.7	15.6	83.3
Kuhner, Karl	Philips, Hamilton Co.	5	204	18.0	15.0	82.4
Kundsen, B.	St. Libory, Howard Co.	1	180	17.7	14.6	83.4
Kutschkan, Gus	Grand Island	3	151	21.0	17.5	81.3
Lamsen, John	Dannebrog, Howard Co.	1	110	19.2	15.6	84.5
Lange, Henry	do	12	351	18.5	15.6	86.8
Lange, H.	Grand Island	11	170	20.4	17.8	83.9
Lassen, Conrad	do	5	290	17.5	14.3	83.6
Leppin, Wm	do	12	168	19.5	16.2	82.9
Leppin, Christ	do	11	161	22.8	18.6	81.1
Linden, John P.	do	5	277	17.2	14.0	83.4
Lilienthal, H.	do	17	247	19.2	16.1	84.8
Linelstrom, M. J.	Boelus, Howard Co.	1	187	21.0	17.8	81.2
Lopmann, Wilhelm	Grand Island	11	175	20.3	16.5	88.9
Long, T. M.	St. Michael, Buffalo Co.	1	101	19.9	17.7	84.9
Lübs, Henry	Alda, Hall Co.	2	261	21.5	18.3	83.4
Luth, Fred	Grand Island	5	201	16.1	15.1	85.4
Lübbe, Claus	do	19	254	19.5	16.5	156.7
Lyons, Miles	Wood River, Hall Co.	1	261	21.0	16.9	83.4
Marshall, John	Columbus, Platt Co.	1	237	18.7	15.6	83.1
Martin, David	Central City, Merrick Co.	1	274	20.1	16.7	81.3
Marshall, Thos. F.	Columbus, Platt Co.	1	207	18.2	14.8	83.2
Madson, P. Ch	Dannebrog, Howard Co.	1	388	19.7	16.4	82.6
Marshall, Jas	Columbus, Platt Co.	1	269	19.5	16.1	

Name.	Post-office address.	No. of sam- ples.	Aver- age weight of beet.	Total solids indica- ted by Brix spindle.	Sucrose in juice.	Purity coeffi- cient.
			<i>Grams.</i>	<i>Pr. ct.</i>	<i>Pr. ct.</i>	
Martin, J. B.	Schuyler, Colfax Co.	2	374	20.7	16.7	80.5
Martin, J. L.	Chapman, Merrick Co.	3	360	18.8	15.7	83.3
McKee and H. B. Wray.	Alda, Hall Co.	5	200	19.8	16.6	82.5
McDaniel, W. R.	Cairo, Hall Co.	1	151	20.5	18.5	90.2
McLain, R.	Fremont, Dodge Co.	1	271	18.8	15.7	83.4
McIntosh, W. G.	Rockville, Sherman Co.	1	117	20.2	16.8	83.1
Mettembrick, C.	Grand Island.	13	211	19.0	15.9	83.3
Melson, L.	Dannebrog, Howard Co.	1	138	20.2	16.7	82.7
Mildenskein, N.	Grand Island.	6	195	18.8	15.5	82.2
Millard, C. E.	O'Neill, Holt Co.	2	278	20.3	16.3	81.6
Mitchell, Robert.	Grand Island.	13	238	18.4	15.0	82.1
Mohr, John	do	4	313	19.8	16.9	84.4
Morse, Marenas	Clarks, Merrick Co.	4	270	20.4	16.7	82.3
Moody, J. L.	Scotia, Greeley Co.	2	274	18.8	15.6	82.7
Mohr, Peter	Grand Island.	11	285	19.1	16.2	84.5
Moore, P. C.	Central City, Merrick Co.	1	407	20.0	16.0	80.0
Morris, C. H.	Chapman, Merrick Co.	1	160	23.5	18.2	.....
Morey, Gordon	Cairo, Hall Co.	1	231	20.5	17.5	85.4
Mueller, Ludwig	Chapman, Merrick Co.	4	193	17.9	14.8	82.5
Muhl, Peter	do	2	209	22.1	18.5	83.9
McMullen, R.	Grand Island.	11	265	18.6	15.4	83.2
Myers, John	Shelton, Hall Co.	1	272	23.7	20.2	85.2
Naffke, Carl	Grand Island.	15	321	18.6	15.6	83.3
Navy, Wenzel	Ravenna, Buffalo Co.	2	249	21.7	17.8	82.3
Neubert, Johann	Grand Island.	13	254	18.8	15.3	81.5
Neubert, John	do	3	164	20.4	17.1	85.3
Nerilla, M. T.	Wood River, Hall Co.	1	273	21.4	17.9	83.6
Nelson, N.	Dannebrog, Howard Co.	1	264	19.8	17.0	85.8
Nieturger, Christian	Grand Island.	4	246	21.6	18.7	86.4
Nietfeld, Wm.	do	7	307	19.2	16.1	82.9
Nissen, Chr.	do	4	192	20.0	17.0	81.2
Nietfeld, Henry	do	2	203	21.0	17.4	82.8
Nichols, H. W.	St. Paul, Howard Co.	1	211	21.8	18.7	85.8
Nietfeld, Fritz	Grand Island.	1	161	19.7	16.6	84.3
Noack, Ernst	Shelton, Buffalo Co.	2	111	21.2	17.6	83.0
Norris, C. E.	Ravenna, Buffalo Co.	1	283	20.1	16.7	83.0
Obermeyer, Henry	Grand Island.	11	196	18.8	15.4	82.2
Ohlmann, Fred	Shelton, Buffalo Co.	1	282	22.4	21.3	82.0
Oltmann, John	Grand Island.	9	257	20.9	17.3	82.9
Olsen, Fred	Nysted, Howard Co.	6	247	19.9	16.3	82.6
Onist, J. D.	Shelton, Buffalo Co.	1	327	23.2	19.2	82.7
Orndorff, Peter	Alda, Hall Co.	1	189	20.2	16.2	.....
Pahl, Hans.	Grand Island, Hall Co.	3	208	20.2	17.4	85.8
Paustian, G.	do	12	284	20.1	16.5	82.0
Peters, C. T.	St. Libory, Howard Co.	2	211	19.8	16.9	85.2
Petzald, Louis	Grand Island, Hall Co.	4	343	20.4	17.1	83.6
Peters, C. T.	St. Libory, Howard Co.	3	290	20.3	16.8	82.6
Peterson, W. C.	Fremont, Dodge Co.	1	412	17.7	14.7	79.6
Peterson, H. P.	Dannebrog, Howard Co.	1	189	19.2	15.5	.....
Pitrek, Chas	Ravenna, Buffalo Co.	2	173	21.2	17.4	83.1
Pieffer, Henry	Grand Island, Hall Co.	6	174	20.2	16.9	83.6
Pickett, James	Ravenna, Buffalo Co.	1	145	18.4	14.4	78.8
Pitrick, John	Ravenna, Buffalo Co.	1	170	20.1	15.7	.....
Pohl, Jacob	Grand Island, Hall Co.	4	333	20.5	17.3	84.0
Polenz, Julius	Ravenna, Buffalo Co.	1	367	18.6	15.7	.....
Prudy, H. G., and Laun- born.	Lawrence, Nuckolls Co.	6	265	20.8	17.6	84.6
Puchert, Chas	Ravenna, Buffalo Co.	1	.....	20.5	15.5	75.6
Rochler, H.	Grand Island, Hall Co.	5	115	22.3	18.3	82.5
Rapp, L. F.	Broken Bow, Custer Co.	1	403	19.4	15.1	77.8
Rasmussen, Jens	Dannebrog, Howard Co.	1	140	19.5	16.5	.....
Raunert, Mathias	Grand Island, Hall Co.	6	253	18.5	15.3	82.7
Rasmussen, H. C.	Chapman, Merrick Co.	5	234	17.7	14.4	81.3
Rein, Olsen	St. Libory, Howard Co.	2	191	17.1	14.5	84.9
Reher, Chr.	Grand Island, Hall Co.	17	310	18.6	15.5	83.1
Remlo, Fred	do	4	139	18.6	15.4	82.1
Reher, John Fred	do	13	194	20.1	17.5	87.0
Reid, J. H., and Son	Columbus, Platte Co.	1	243	20.2	17.4	86.1
Reynier, H.	Broken Bow, Custer Co.	1	236	23.5	19.2	81.7
Richardson, D.	Alda, Hall Co.	3	217	19.5	16.1	84.4
Ritterbush, H.	Grand Island, Hall Co.	2	262	19.9	16.5	83.1
Rizoe, A. J.	do	3	114	20.4	17.5	85.7
Richter, Aug	Doniphan, Hall Co.	1	402	18.8	15.9	84.6
Rieff, Henry	Grand Island, Hall Co.	1	337	21.3	18.9	88.7
Rowe, D.	Fremont, Dodge Co.	2	419	18.4	14.6	79.2
Rosk, Frank	St. Libory, Howard Co.	2	290	18.6	16.1	87.2
Rosenkalter, Carl	Grand Island, Hall Co.	13	171	19.8	16.5	83.4
Rosswick, Henry	Cairo, Hall Co.	2	205	18.7	14.9	80.0
Roby, Gustav	Grand Island, Hall Co.	8	297	19.5	16.4	82.9

Name.	Post-office address.	No. of sam- ples.	Aver- age weight of beet.	Total solids indica- ted by Brix spindle.	Sucrose in juice.	Purity coefficient.
			<i>Grams.</i>	<i>Pr. ct.</i>	<i>Pr. ct.</i>	
Roby, Fred	Grand Island, Hall Co	17	220	19.4	16.2	88.2
Rohweder, Henry	do	1	183	18.8	14.6	
Rohling, Fr.	Kelsa, Howard Co	1	222	17.4	13.0	74.1
Ropke, Heinrich	St. Libory, Howard Co.	1	375	20.3	15.9	73.4
Russell, J. B.	Grand Island, Hall Co.	4	218	19.8	16.7	84.6
Ruge, Hans	do	5	173	20.2	17.2	86.2
Ruttstson, Ch. J.	Boelus, Howard Co.	1	215	21.2	17.9	84.4
Russell, G. W.	St. Paul, Howard Co.	1		21.0	18.2	85.7
Salyards, David	Richland, Colfax Co.	1	200	19.4	17.0	87.6
Schmidt, Ernst	Fremont, Dodge Co.	1	402	17.4	15.0	84.3
Schroeder, Wm	Columbus, Platte Co.	1	204	19.4	16.2	83.4
Schlund, Nat.	St. Michael, Buffalo Co.	1	126	18.1	15.1	83.4
Schaubdach, Chi	Alda, Hall Co.	9	336	20.2	16.7	82.8
Schrnale, Carl	Grand Island, Hall Co	7	192	19.7	16.1	81.6
Schultz, John	do	12	208	17.9	14.8	83.3
Schleichardt, Fr	do	14	247	19.7	16.1	81.7
Schultz, Ludwig	do	13	286	21.1	18.2	85.9
Schroeder, Fritz	Alda, Hall Co.	8	237	18.3	15.4	84.1
Schuldt, John	Schuyler, Colfax Co.	2	317	18.9	14.9	78.6
Schuster, Heinrich	Phillips, Hamilton Co	3	242	18.9	15.7	83.0
Schinkel, John	Grand Island, Hall Co	4	235	18.3	14.1	77.4
Schmale, H	do	7	200	18.6	16.4	83.2
Schultz, Peter	Cairo, Hall Co.	7	215	20.2	17.3	85.2
Schoenstein, Alb.	Grand Island, Hall Co	2	166	18.5	15.3	82.6
Schimmer, Henry	do	14	255	18.8	15.7	83.1
Schipmann, H	do	4	196	20.9	18.2	88.0
Schultz, Ernst	do	5	358	19.7	17.1	86.5
Scherzbeig, C	do	7	336	20.1	16.4	81.5
Serei, John	Grand Island, Hall Co	9	197	20.7	15.9	77.5
Seehusen, John	Dannebrog, Howard Co.	2	227	19.0	14.8	
Senkbeil, Rud.	Grand Island, Hall Co	8	246	18.4	15.2	63.0
Sears, C. H.	Clarks, Merrick Co	2	158	21.3	18.3	85.8
Seibert, Reed	Grand Island, Hall Co.	4	222	19.4	15.8	82.3
Seifert, David	Boelus, Howard Co.	1	289	16.8	13.0	77.2
Shipman, H	Grand Island, Hall Co.	2	270	17.4	13.2	75.6
Shoof, Henry	Oconel, Platte Co	3	197	19.8	16.5	82.9
Shoman, Wm	Clarks, Merrick Co	1	135	19.3	16.2	83.9
Silvers, Theo.	Grand Island, Hall Co.	4		19.1	15.4	
Sigman, Walter	Cairo, Hall Co.	1	192	18.3	15.4	
Skoogard, C. T.	Nysted, Howard Co.	3	280	20.3	17.2	85.8
Smithwick, M	Grand Island, Hall Co.	17	198	20.1	17.3	86.6
Smith, Alex.	Seward, Seward Co.	2	245	17.9	14.0	78.1
Smith, A. O	Central City, Merrick Co	2	312	20.4	16.9	83.0
Sondermeyer, Caspar	Grand Island, Hall Co.	11	223	19.5	15.7	80.8
Sothman, Gus	Shelton, Buffalo Co.	2	305	20.3	17.6	86.8
Sorensen, E. H.	Dannebrog, Howard Co.	1	232	20.5	16.3	79.5
Sothman, Claus	St. Michael, Buffalo Co.	1	117	21.4	19.0	88.7
Spethman, Leopold	Grand Island, Hall Co.	7	184	18.8	16.1	83.6
Spech, N. and McEl-	Cairo, Hall Co	1	354	20.4	16.5	
henny, D.						
Specht, Nat.	St. Michael, Buffalo Co.	1		15.8	13.1	82.9
Stuhr, Hans	Grand Island, Hall Co.	16	250	18.9	15.8	83.3
Steinbeck, Diedt	do	3	202	19.4	16.0	82.3
Steinbeig, H.	do	2	184	19.0	15.4	81.9
Stuhr, Geb.	do	6	384	17.8	14.4	80.7
Stalt, Hans	do	3	288	20.5	17.7	82.9
Stegemann, Ernst	Marquette, Hamilton Co.	3	275	17.3	13.9	80.1
Stiller, Wilhelm	Grand Island, Hall Co.	9	210	18.8	15.2	82.0
Stoltenberg, Claus	do	15	246	20.3	17.3	84.4
Steinmeyer, H	do	5		16.6	13.5	85.0
Stepe, Henry	do	1	136	19.9	16.2	81.9
Sundbeig, E. N.	Dannebrog, Howard Co	2	130	18.9	15.1	83.6
Sneplsen, Fritz	Grand Island, Hall Co	1		18.6	15.9	
Taylor, T. W.	Columbus, Platte Co	1	113	20.4	18.3	89.7
Taylor, F. N.	Wood River, Hall Co.	1	187	21.2	17.4	82.0
Taylor, John R	Seward, Seward Co.	1	165	18.8	15.3	81.3
Thavernet, G	Grand Island, Hall Co	2		15.5	14.0	89.6
Thompson, John	do	14	218	19.5	16.5	84.7
Thomas, C. N	Chapman, Merrick Co.	1	171	17.8	13.7	71.3
Thacker, W. R.	Ravenna, Buffalo Co.	1		16.1	13.1	81.4
Tinge, C.	St. Libory, Howard Co	1	343	15.2	12.2	80.2
Tomanch, Fr.	Nimberg, Butler Co	1	335	21.4	18.8	87.8
Tolkey, John	Rockville, Sherman Co	1	191	17.9	15.2	84.9
Trummer, Hermann	Grand Island, Hall Co.	8	250	20.5	17.3	86.5
Turner, N. H.	Columbus, Platte Co.	1	161	21.8	19.6	89.9
Underhill, I. C.	Cairo, Hall Co	1	343	18.8	15.5	82.5
Unger, August	St. Michael, Buffalo Co.	1		17.8	14.2	79.8
Vaudt, Chas	Clarks, Merrick Co	1	125	18.9	15.9	85.9
Veeder, W. H.	Grand Island, Hall Co.	1	180	20.2	17.0	84.1

Name.	Post-office address.	No. of samples.	Average weight of beet.	Total solids indicated by Brix spindle.	Sucrose in juice.	Purity coefficient.
			<i>Grams.</i>	<i>Pr. ct.</i>	<i>Pr. ct.</i>	
Vocke, Herman H.	Grand Island, Hall Co.	1	229	21.2	17.8	83.9
Voss, Hans.	do.	18	261	19.1	15.7	82.6
Vose, Heinrich.	do.	3	149	18.6	15.3	82.0
Wallter, Aug.	Palmer, Merrick Co.	1	230	20.6	18.4	89.3
Wagner, Bernhard.	St. Libory, Howard Co.	1	147	20.8	17.1	82.2
Waters, George.	Clarks, Merrick Co.	1	121	18.8	15.7	88.9
Wagner, Traugott.	Grand Island, Hall Co.	5	354	18.1	14.5	80.1
Wagner, Christ.	St. Libory, Howard Co.	11	323	18.9	15.7	83.4
Ward, C. E. & Co.	Belvidere, Thayer Co.	2	279	19.9	16.3	79.8
West, W. H.	Cairo, Hall Co.	1	.....	17.2	13.9	.....
Wells & Wieman.	Schuyler, Colfax Co.	11	478	20.2	15.7	77.6
Wegner, Herman.	Grand Island, Hall Co.	13	253	19.7	16.2	81.5
Werner, Franz B.	do.	11	268	19.8	17.0	86.2
Weiss, Fred.	do.	9	235	18.9	15.1	79.9
Weinhold, Paul and Weyer H.	do.	6	190	20.3	17.6	86.5
Weller, Conrad.	do.	12	234	20.9	18.3	83.5
Wheeler, Jasel.	Bromfield, Hamilton Co.	2	213	20.2	17.4	85.9
Witt, C. F.	Grand Island, Hall Co.	1	416	20.6	17.3	83.9
Witt, Heinrich G.	Rockville, Sherman Co.	1	101	19.6	16.9	86.2
Wiene, Bernt.	Bromfield, Hamilton Co.	1	.....	.....	.....	.....
Wissink, Jan.	St. Libory, Howard Co.	1	.....	17.7	15.4	87.0
Wienhake, Heinrich.	Grand Island, Hall Co.	3	205	19.6	15.8	80.4
Windolph, Adam.	do.	9	332	20.0	16.6	83.6
Williams, W. T. and W. G.	Alda, Hall Co.	3	278	19.7	16.1	61.6
Wines, E. J.	Grand Island, Hall Co.	17	260	19.6	16.6	84.2
Wilkelmie, Wilh.	Chapman, Merrick Co.	8	195	18.3	14.9	81.0
Windolph, C.	Grand Island, Hall Co.	19	193	19.3	16.2	83.1
Wiese, Wm.	do.	3	280	18.3	15.2	82.6
Will, Wm.	Columbus, Platte Co.	3	250	20.7	17.2	82.8
Witt, Wilhelm.	Alda, Hall Co.	3	161	19.2	15.5	82.8
Woodworth, T. L.	Chapman, Merrick Co.	2	141	19.5	15.9	81.3
Wulf, Wilhelm.	Grand Island, Hall Co.	8	208	18.7	14.8	79.5
Yesson, Peter.	Chapman, Merrick Co.	4	271	19.2	16.4	85.6
Do.	do.	1	200	18.5	14.7	74.0
Yohnik, Henry.	do.	23	333	20.0	16.5	83.9
Zehrke, Julius.	Ravenna, Buffalo Co.	1	148	19.5	16.0	82.0
Zeleny, Jos.	Nimberg, Butler Co.	1	335	21.4	18.8	78.8
Zlanke, E.	Grand Island, Hall Co.	6	243	19.4	16.1	84.2
Tamsen, Fritz.	Alda, Hall Co.	6	197	19.9	15.7	78.5
Means. ....	.....	.....	238.9	19.6	16.3	83.2

Total number of samples, 1,866.

CHARACTER OF BEETS DELIVERED TO THE GRAND ISLAND FACTORY.

Through the courtesy of Mr. H. T. Oxnard the Department was allowed to establish a laboratory in the sugar factory at Grand Island for the purpose of obtaining information in regard to the character of the beets entering into manufacture. In all about three thousand samples of beets were examined, a sample having been taken from every wagonload and every carload of beets delivered to the factory. These samples were taken in such a way as to give as nearly as possible the average character of all the beets worked. A large number of beets was taken from each sample, and after they had been properly cleaned and dried their average weight was taken. The beets were then rasped, the juice expressed, and an analysis made on the expressed juice. The total solid matter was determined by a specific-gravity spindle, and the percentage of sucrose in the juice was estimated by the polariscope. The purity efficient was determined by dividing the percentage of sucrose in the juice as indicated by the polariscope by the percentage of total solids as indicated by the spindle.

AVERAGE WEIGHT OF BEETS.

The average weight of all the beets examined was 238.9 grammes. This small size of the beet was doubtless due to the extremely dry season. The drought throughout the region covered by the sugar-beet fields was the most severe perhaps that has ever been known in the State of Nebraska. Ordinary crops such as corn were almost total failures, and it is a matter of encouragement to note that in such a season the beets, although not making an average yield, yet did fairly well. On the whole, however, it must be confessed that the results from an agricultural point of view were disappointing; but this disappointment must be chiefly attributed to the exceptionally severe drought already mentioned.

It is also doubtless true that in the practice of the new system of agriculture which is required for the proper production of sugar beets many failures were made, and perhaps very few of the farmers practiced that form of agriculture which was best suited to the soil and the season. In a soil which is apt to be dry, as in Nebraska, too much attention can not be paid to the importance of loosening the ground to a good depth. Deep plowing, followed by deep subsoiling, together with such harrowing and other treatment of the surface as will produce a perfect tilth, are absolutely essential to the production of a profitable crop.

The remarkably high percentage of sucrose shown in the juice is an evidence of the fact that the soil and climate of Nebraska are favorable to the production of a beet rich in crystallizable sugar. It must, however, not be forgotten that the extremely high percentage of sucrose in the juice is probably a reciprocal of the small size of the beet due to the dry season. Had the season been favorable to the production of a beet of average size, with a tonnage of from 15 to 20 per acre, the percentage of sucrose in the beets would doubtless have been less. This is well illustrated in the data obtained in the Department from the analysis of sugar beets sent from Nebraska. It is evident from the character of the samples which were received by the Department that the farmers have selected the larger beets to be sent on for analysis. It is seen by comparison of the respective sizes of the beets received for analysis by the Department with those received for manufacture at Grand Island that the beets sent on for analysis were about three times the size of those manufactured into sugar. It will also be noticed that in the beets received for analysis by the Department the percentage of sucrose is low as compared with those which entered into manufacture at Grand Island. It would therefore hardly be just to claim that beets as rich as those manufactured at Grand Island during the past season can be grown in quantities of from 15 to 20 tons per acre. It is not a matter of surprise that many of the farmers who grew beets are discouraged at the results of the first year's work. The planting and cultivation of the sugar beet, as is well known, are matters which require

great labor and expense, and when, therefore, an unfavorable season cuts the crop very short, it is but natural that the farmer should be discontented. It is, however, difficult to see how he could have done better with any other crop, and the fact that in many instances even with the present dry season the farmers of Nebraska were able to grow 10 or even 15 tons per acre, shows that with proper cultivation and proper attention in other ways to the growing crop the evils which attend a severe drought can be greatly mitigated if not altogether avoided. It is not the purpose of the Department to encourage farmers to engage in an industry which does not give promise of success; but it will be a matter of regret to every one who desires to see the success of the sugar industry if the discontent which naturally attends a very unfavorable season should be sufficient to deter farmers from continuing the cultivation of a crop which under ordinary conditions promises so fair a yield as sugar beets. It would be wiser on the part of the farmers to continue the cultivation of the sugar-beet until it has been demonstrated at least that even with favorable years it is not profitable. In that case it would be necessary to cease the cultivation of a crop which afforded no prospect of financial success.

EXPERIMENTS WITH SUGAR BEETS IN WISCONSIN.

Extensive experiments were carried on in Wisconsin during the season of 1891 by the Department in coöperation with the agricultural experiment station under direction of Prof. W. A. Henry.

The general directions for the work were given by the Department, but all the details thereof were left to the supervision of Professor Henry.

The results of the work were encouraging, and its data, arranged by F. W. Woll, chemist of the station, will be found following:

Seeds of the following six varieties of sugar beets were received from the U. S. Department of Agriculture in the beginning of May: Dippe's Vilmorin, Dippe's Klein Wanzlebener, Simon Legrand's White Improved, Bulteau Desprez Richest, and Lemaire's Richest. About 3 acres of land were prepared at the experiment farm for beet culture, and divided up between the varieties in proportion to the quantity of seed on hand. Arrangements were further made with five farmers living in different parts of the State to grow three of the varieties, viz: Simon Legrand's White Improved, Bulteau Desprez Richest, and Dippe's Klein Wanzlebener, on a piece of land, 3 square rods for each variety; to send samples of the beets grown at different times for examination of sugar content, and to report the results as regards culture and yield. Notice was given in the newspapers that a supply of sugar-beet seed was on hand for distribution among farmers who would investigate the adaptability of their soils for sugar-beet culture, with the obligation to send samples of the beets grown for analysis. In this way, samples of beets from seventy farmers were received and analyzed;

about half of these received their seed from the station, and the majority of the rest received seed directly from the U. S. Department of Agriculture.

First are given the results of the beet culture at the station, then those of the culture at substations, and finally the results of examinations of beets grown by farmers in different parts of this State.

SUGAR-BEET CULTURE AT WISCONSIN AGRICULTURAL EXPERIMENT STATION, SEASON 1890.

Two plats, $1\frac{1}{2}$ and $1\frac{1}{2}$ acres, were set apart for sugar beets during the spring of 1890. Potatoes had been grown on Plat A the preceding year; on Plat B clover was grown the preceding year, and the land plowed that fall; the soil was a light clay, a portion of Plat B being a sandy loam. The beets were planted in rows 20 inches apart on Plat A, with beets every 8 inches in the row, the following varieties were planted on May 27 on this plat: Dippe's Klein Wanzlebener, Simon Legrand's White Improved, Bulteau Desprez Richest, and Dippe's Vilmorin. On the other plat (Plat B) the beets were planted in rows 30 inches, with beets every 10 inches in the row; the following varieties were planted in this way on May 28: Florimond Desprez Richest, Lemaire's Richest, and Dippe's Vilmorin. The seed of the last variety was divided between the plats, so as to determine the influence of different thickness of planting on the yield of beets.

The beets received the very best treatment during their period of growth that the circumstances would allow. The heavy rains in the beginning and middle of June made cultivation impossible for a time, and gave the weeds more of a start than they would otherwise have had. The cultivation was done partly by a harrow tooth cultivator, or by a wheel hoe and shovel attachment with shields, or by hand. The weeds in the rows between the beets could not be reached in any other than by a hand hoe. The features of the growing season were plenty of rain in May, June, August, and October, with a temperature somewhat below normal during May, August, and September, and higher than normal in June. The main meteorological data for the season are given in the following table:

Meteorological data for summer, 1890, for Madison, Wis.

[From observations made at Washburn Observatory.]

Month.	Temperature.				Rainfall.	
	Max.	Min.	Mean.	Mean normal.	1890.	Normal.
	°F.	°F.	°F.	°F.	Inches.	Inches.
May	84	33	53.0	57.8	5.03	3.64
June	93	50	70.6	67.2	7.72	4.42
July	91	54	71.7	72.7	1.81	4.19
August	93	46	66.1	69.4	4.23	3.28
September	83	36	57.4	61.0	2.62	3.35
October	69	25	48.2	48.5	4.59	2.87
Total					25.00	21.75

Samples of the beets grown were taken every week from September 5 on. Three to four beets of every variety of what seemed average size were pulled and the average sugar content in the same ascertained by the polariscope. While it is not believed that the beets sampled in every case represented exactly the stage of growth of each variety at the time, the analysis may indicate in a general way the increase in sugar content and in the purity of the juice of the beets. The following table gives the results of the weekly examinations of each plat. The average weight of the beets sampled is also given :

PLAT A.

[Distance between rows, 20 inches ; between beets in the row, 8 inches.]

Date.	Dippe's Vilmorin.			Bulteau Desprez.			Klein Wanzlebener.			Simon Legrand.			Average sucrose in juice.	Purity coefficient.
	Average weight of beets.	Sucrose in juice.	Purity coefficient.	Average weight of beets.	Sucrose in juice.	Purity coefficient.	Average weight of beets.	Sucrose in juice.	Purity coefficient.	Average weight of beets.	Sucrose in juice.	Purity coefficient.		
Sept. 5	452	11.87	78.2	239	10.79	73.4	355	11.77	77.5	476	11.81	82.9	11.56	78.0
15	551	12.91	86.6	578	12.72	80.2	482	13.02	83.4	591	12.51	77.7	12.79	82.0
22	453	15.29	85.3	631	13.87	83.1	472	14.74	83.3	640	13.38	82.6	14.27	83.6
30	401	15.78	86.9	604	15.27	84.1	409	14.06	82.7	495	15.38	84.7	15.12	84.6
Oct. 7	535	17.64	85.6	574	14.85	83.9	588	16.14	83.7	388	16.68	87.1	16.33	85.1
16	670	*15.43	84.5	561	15.52	86.1	486	14.33	84.8	900	14.60	84.2	14.97	84.9
23	419	16.01	85.0	324	16.03	87.2	547	15.92	87.7	506	16.15	83.8	16.03	85.9
30	566	16.76	86.3	567	14.81	83.9	407	16.39	82.2	686	15.74	83.2	15.93	83.9

* A sample taken October 17 gave 16.37 per cent of sugar ; purity coefficient, 84.9 ; average weight of beets, 527 grammes.

PLAT B.

[Distance between rows, 30 inches ; between beets in the row, 10 inches.]

Date.	Dippe's Vilmorin.			Lemaire's richest.			Florimond Desprez Richest			Average sucrose in juice.	Purity coefficient.
	Average weight of beets.	Sucrose in juice.	Purity coefficient.	Average weight of beets.	Sucrose in juice.	Purity coefficient.	Average weight of beets.	Sucrose in juice.	Purity coefficient.		
Sept. 9	Grams.	Per ct.		Grams.	Per ct.		Grams.	Per cent.		Per ct.	
15	528	13.08	76.9	963	10.76	79.5	656	10.05	71.7	11.30	76.0
22	492	12.17	80.1	637	9.88	74.3	792	10.14	72.5	10.73	75.6
30	388	16.05	87.3	713	14.09	85.8	672	11.45	79.5	13.86	84.2
Oct. 7	403	17.32	84.9	576	14.37	83.8	1,107	13.44	82.9	15.04	83.9
16	512	16.10	84.9	712	14.56	83.5	612	12.59	79.5	14.42	83.0
24	642	17.30	84.8	1,049	14.52	80.0	887	13.80	81.6	15.21	82.1
Nov. 1	540	15.57	84.7	731	14.98	83.2	886	12.83	78.7	14.45	82.2
	588	15.74	86.0	1,031	16.32	82.8	905	14.84	82.4	15.63	83.7

Perfectly representative samples were not always secured, as will be seen, but the analyses show nevertheless in a general way the change in the sugar content of the juice and its purity with the advance of the season. The last series of determinations for both plats were made at harvesting time ; the results given for this State (November 1) are the averages of three samples of beets, of four each, taken from different parts of the plat, the beets being average sized and, as nearly as could be, representative ones. The beets reached full maturity, as may be

inferred from the above table, from September 30 to October 7; after that time the percentage of sugar in the beets remained about stationary. As regards the possible yield at that early period we have no data to judge from except that the weights of the beets sampled might indicate that there was no material increase after that period.

As the varying percentages found at the different periods doubtless stand in a definite relation to the rainfall, we give below the days on which rain fell at this place between September 1 and November 1:

Rainfall at Madison, Wis., September and October, 1890.

Date.	Amount.	Date.	Amount.	Date.	Amount.	Date.	Amount.
	<i>Inches.</i>		<i>Inches.</i>		<i>Inches.</i>		<i>Inches.</i>
Sept. 3	0.18	Oct. 9	0.56	Sept. 25	0.08	29	trace
4	1.81	11	0.64	26	trace	31	0.01
6	trace	12	0.98	Oct. 1	0.03		
7	0.02	13	0.52	2	0.23		
12	trace	15	0.23	3	trace		
15	0.38	16	trace	4	0.08		
17	trace	18	0.72	5	trace		
18	trace	25	0.31	6	0.12		
19	0.15	26	trace	7	0.16		

DATA OBTAINED AT HARVESTING TIME.

[October 30 to November 1.]

The area taken up by each variety and the yield of beets as ascertained at harvesting time are given here:

Variety.	Area grown.	Yield.	Sugar in the juice.
	<i>Sq. feet.</i>	<i>Pounds.</i>	<i>Per cent.</i>
Plat A:			
Dippe's Vilmorin	2,470	3,040	16.76
Bulteau Desprez Richest	8,352	11,804	14.81
Simon Legrand	26,375	27,866	16.39
Klein Wanzlebener	28,750	25,650	15.74
Plat B:			
Dippe's Vilmorin	13,311	11,920	15.74
Lemaire's Richest	22,264	21,006	16.32
Florimond Desprez Richest	20,685	24,844	14.84

A good deal of dirt adhered to the beets as they were weighed. In order to ascertain the yield per acre of washed beets, a basketful of each load of beets was taken out and weighed, each variety being kept by itself; when all loads from each variety had been taken from the field, the beets taken out were all carefully washed, dried, and weighed. In this way the percentages of dirt adhering to the beets were ascertained, as follows:

Plat A:	Per cent.
Vilmorin	24.79
Bulteau Desprez	15.70
Simon Legrand	13.10
Klein Wanzlebener	12.11
Plat B:	
Vilmorin	24.23
Lemaire	15.70
Florimond Desprez	10.52

Basing calculations on these figures, we obtain the following yields per acre of washed beets of each variety:

Yield of washed beets.

Plat A (beets 20 by 8 inches apart):	Pounds.
Vilmorin	40,420
Bulteau	51,900
Simon Legrand	39,930
Klein Wanzlebener	34,150
Plat B (beets 30 by 10 inches apart):	
Vilmorin	29,430
Lemaire	34,630
Florimond Desprez	46,710

The data on hand are insufficient to determine the actual yield of sugar per acre in case of each variety. On the supposition that all varieties contained approximately the same percentage of juice, they would rank as follows as regards their sugar-producing capacity: 1. Bulteau Desprez; 2. Vilmorin (plat A); 3. Florimond Desprez; 4. Simon Legrand; 5. Klein Wanzlebener; 6. Lemaire; 7. Vilmorin (plat B).

QUANTITY OF TOPS OBTAINED FROM BEETS.

The tops from a number of beets were weighed separately when the first determination was made, September 5, and also at harvesting time, to obtain some data as regards the proportionate increase of the beet root with the period of growth, and also the relation of leaves to roots with the different varieties.

Proportion of washed roots to leaves.

Plat A:	Roots : leaves as 100 :
Vilmorin, September 5	60
November 1	34
Bulteau Deprez, September 5	132
October 31	17
Simon Legrand, September 5	68
October 30	23
Klein Wanzlebener, September 5	79
November 1	—
Plat B:	
Vilmorin, September 9	84
November 1	37
Lemaire, September 9	79
November 1	36
Florimond Desprez, September 9	66
November 1	36

As has always been found, the proportion of leaves is larger in the earlier stages of growth. Between the different varieties there is some difference, Bulteau Desprez and Simon Legrand White Improved containing a smaller proportion of leaves at the time of harvesting than the other varieties.

Summing up the discussion of the work for the last season it is noticed that the yield of sugar beets obtained as well as their sugar content was very satisfactory; the season could not be considered favorable to sugar-beet culture on account of the heavy rains in the fall. When, in spite of this, crops were secured of 15 to 25 tons per acre of beets, containing a good percentage of sugar, it would seem that the question whether or not sugar-beet culture may prove profitable can not be answered in any other way than the affirmative.

WORK DONE AT SUB-STATIONS.

Five sub-stations were established in different parts of the State to study the adaptability of the different regions to sugar-beet culture. The names of the farmers who undertook the work with their addresses are F. W. Roberts, Woodworth, Kenosha County; Paul M. Peirce, Germania, Marquette County; Fred. Burton, Janesville, Rock County; L. F. Noyes, Hudson, St. Croix County; A. L. Grengo, Colgate, Waukesha County.

Of these stations three lie in the southern portion of our State, viz: Woodworth, near Lake Michigan; Janesville at about the same latitude in the inner part of the State; and Colgate about 20 miles west of Milwaukee. Germania lies in the central portion of the State, about 50 miles north of Madison; Hudson lies in the northwestern corner of the State, about 10 miles east of St. Paul (at 45° latitude).

Directions were sent to select a small piece of land, about 3 square rods, of a kind that would be favorable to a good crop of potatoes; to give the beets good cultivation, and to keep careful notes as regards labor spent and method of planting and cultivation. The following varieties were sent to each sub-station: Bulteau Desprez Richest, Simon Legrand's White Improved, and Dippe's Klein Wanzlebener. The data as to the kind of soil, time of planting, etc., are given in the following table:

Data concerning sub-stations.

Name of sub-station.	Kind of soil.	Planted to each variety.	Previous crop on land.	Date of planting.	Distance between rows.	Distance between beets after last thinning.	Time spent in cultivating and thinning.	Date of harvesting.
		<i>Sq. ft.</i>			<i>In.</i>	<i>In.</i>	<i>Hrs.</i>	
Woodworth, Kenosha Co...	Light sandy..	797	Potatoes..	May 29	18	4-6	24	Oct. 23
Germania, Marquette Co...	Loam	550	Clover ..	May 19	18	6	45	Oct. 23
Janesville, Rock Co	Black loam...	817	Pasture...	May 15	20	8	37	Oct. 23
Hudson, St. Croix Co	Black sandy..	817	Oats ..	May 19	18	(*)	20	Oct. 29
Colgate, Waukesha Co.....	Clay loam....	1,224	Timothy..	May 31	18	8	54	Nov. 16

* Simon Legrand, 16 inches; Klein Wanzlebener, 12 inches; Bulteau Desprez Richest, 20 inches. Seed did not all grow, hence the great distance between beets in the row.

In order to study the development of the beets at each place, during the fall four samples of each variety grown were secured from each station between the middle of September and the date of harvesting. On the arrival of the samples at the station they were weighed and the juice polarized. The results of the examinations are given in the following table.

Sugar beets from substations.

1. FROM F. W. ROBERTS, WOODWORTH, WIS.

Date.	Bulteau-Desprez Rich- est.			Simon Legrand White Improved.			Dippe's Klein-Wanzle- bener.		
	Aver- age weight of beets.	Sugar in juice.	Purity coeffi- cient.	Aver- age weight of beets.	Sucrose in juice.	Purity coeffi- cient.	Aver- age weight of beets.	Sucrose in juice.	Purity coeffi- cient.
	<i>Grams.</i>	<i>Per ct.</i>		<i>Grams.</i>	<i>Per ct.</i>		<i>Grams.</i>	<i>Per ct.</i>	
Sept. 18	237	10.72	77.7	455	10.69	80.3	461	12.37	85.3
Oct. 8	458	10.26	75.3	476	12.51	81.2	451	12.91	81.5
" 15	782	9.87	74.9	586	11.77	80.7	816	11.96	79.5
" 30	614	12.81	79.6	578	12.87	78.9	585	13.45	79.6

2. FROM PAUL M. PEIRCE, GERMANIA, WIS.

Sept. 23	325	12.04	80.8	463	12.70	80.1	381	13.93	91.7
Oct. 7	248	12.98	83.1	546	13.41	82.8	555	13.84	85.4
" 18	682	13.58	85.7	428	13.05	82.2	796	13.27	81.9
Nov. 4	722	13.79	83.2	783	13.68	83.2	832	15.50	84.9

3. FROM FRED. BURTON, JANESVILLE, WIS.

Sept. 25	608	15.24	85.1	561	14.14	83.2	687	13.75	77.2
Oct. 8	438	16.00	80.2	418	15.08	82.6	421	14.40	81.9
" 17	483	13.17	83.0	581	15.29	79.8	672	13.80	82.3
Nov. 7	551	14.77	85.2	516	13.04	82.8	479	14.31	83.1

4. FROM L. F. NOYES, HUDSON, WIS.

Sept. 23	197	13.14	78.2	179	13.71	82.8	208	13.91	85.3
Oct. 6	228	14.84	78.8	205	14.13	82.1	164	14.86	83.0
" 20	186	14.89	79.6	179	16.12	79.9	158	16.83	84.4
Nov. 4	203	12.99	75.5	232	13.60	79.0	243	15.44	83.5

5. FROM A. L. GRENGO, COLGATE, WIS.

Sept. 26	504	14.92	86.0	491	14.69	85.4	605	15.10	83.4
Oct. 9	667	16.25	81.4	761	15.07	80.0	1,040	14.42	81.5
" 18	632	12.53	80.7	925	12.77	80.0	1,046	12.51	79.5
Nov. 12	829	17.14	84.5	791	15.95	87.4	1,047	14.95	83.2

It would seem from this table that the beets did not improve materially at any place as far as sugar content and purity of the juice are concerned after the beginning of October. At the Janesville Substation the beets seem to have been as mature and rich on September 25 as at any time later on. At the Hudson Station the beets never grew large (weighing on the average not more than half a pound apiece), and they seem to have been about as far advanced when the first sample

was taken as later on; the light yield is explained by the cold wet weather at Hudson when the seed was planted, causing the seed to rot; potatoes planted there at the same time also rotted.

The mean temperature and rainfall at St. Paul during the past season and normally were as follows:

Meteorological data for St. Paul, Minn., May to October, 1890.

Months.	Temperature.		Rainfall.	Normal rainfall.
	Mean.	Mean normal.		
	°F.	°F.	Inches.	Inches.
May	52.2	58.4	3.66	3.34
June	69.8	67.1	5.29	4.85
July	71.9	71.6	1.87	3.26
August	65.0	69.5	2.20	3.67
September	58.2	58.9	2.73	3.38
October	46.0	47.1	2.79	2.05
Total			18.54	20.55

The other stations produced beets of average size, with a good to fair percentage of sugar. The yields of beets at the different places may be seen from the following table, and also the estimated yield per acre:

Sugar beets from substations.

Name.	Bulteau Desprez.				Simon Legrand.				Klein Wanzlebener.			
	Area grown.	Yield of beets.	Sugar in juice.	Yield per acre.	Area grown.	Yield of beets.	Sugar in juice.	Yield per acre.	Area grown.	Yield of beets.	Sugar in juice.	Yield per acre.
	Sq. ft.	Lbs.	Perct.	Lbs.	Sq. ft.	Lbs.	Perct.	Lbs.	Sq. ft.	Lbs.	Perct.	Lbs.
F. W. Roberts, Woodworth.....	796.75	1,095	11.81	59,880	796.75	915	12.87	50,010	796.75	1,075	13.45	58,790
P. M. Peirce, Germania.....	550.00	410	13.79	32,470	550.00	200	13.68	15,840	550.00	610	15.50	48,310
Fred Burton, Janesville.....	816.75	600	14.77	32,000	816.75	486	13.04	25,880	816.75	575	14.31	30,670
L. F. Noyes, Hudson.....	816.75	163	12.99	8,694	816.75	174	13.60	9,279	816.75	185	15.44	9,868
A. L. Grengo, Colgate	1,224.00	2,093	17.14	77,470	1,224.00	1,851	15.95	67,410	1,224.00	2,146	14.95	76,370

In judging these results, it must be remembered that the area grown was small, and hence the yield per acre must be taken only as an indication of what might be reached under very favorable conditions. The yield found at the Colgate substation is higher than that of any of the other stations, going even up to 38 tons in case of Bulteau Desprez Richest and following closely with the other varieties. The yield of beets as well as their richness may be pronounced satisfactory in all cases except in case of the Hudson station, where the yield was very light, for reasons already stated. The climatic conditions of the four Southern stations probably did not vary very much from those of Madison, which have been previously given.

As it was deemed of some interest, the weights of leaves were ascertained at harvesting time along with those of the beets. In the following table are given the percentage weights of leaves, calculated on weight of beets:

Relation between tops and beets at substations.

Substation.	Bulteau Desprez Richest.	Simon Le- grand White Imp.	Dippe's Klein Wan- zlebener.
	Weight of beet root: weight of tops as 100:		
Germania, Marquette Co	67	60	50
Woodworth, Kenosha Co	55	52	63
Janesville, Rock Co	54	70	67
Hudson, St. Croix Co	40	34	41
Colgate, Waukesha Co	55	59	58
Average	54	55	56

EXAMINATION OF BEETS FROM FARMERS IN DIFFERENT PARTS OF THE STATE.

It remains to give an account of the work done during the past season in analyzing sugar beets grown by farmers in different parts of the State, the seeds having been mostly obtained, either directly or indirectly, from the U. S. Department of Agriculture. Realizing the importance of the sugar-beet problem and the widespread interest in its solution, this station had notices published in all newspapers in the State offering to analyze free of charge beets grown anywhere in the State. As a result, 70 farmers in 28 counties of the State sent in samples of sugar beets for analysis. The results are given in the following table, along with such information about the beets as it was possible to obtain—variety, soil, time of planting and harvesting, etc.:

Sugar beets in Wisconsin, season 1890, arranged alphabetically according to counties.

Number.	Name of grower.	Post-office.	County.	Variety.	Seed obtained from—	Time of planting.	Time of harvesting.	Soil.	Average weight of beets.	Solid in juice.	Sugar in juice.	Purity coefficient.	Remarks.
1	John B. Meyer...	Modena...	Buffalo...	White Siberian...	S Wilson, Mechanicsville, Pa.	May 3	Oct. 20	Black prairie...	Grass P. et P. et.				
2	Henry N. Petersen	New Holstein...	Calumet...	Klein Wanzleben.	U. S. Department Agriculture.	Mid. May	Oct. 23	Black loam...	1, 135 14.48	10.29	71.2		
3	Herm. Kroehnke	do	do	do	do	May 20	Nov. 5	Loam...	402 21.40	17.91	83.7		
4	Claus Edens...	do	do	Klein Wanzleben.	do	May 20	Nov. 1	Dark loam...	549 18.60	16.20	87.1		8 inches apart, rows 16 inch.
5	Aug. A. Paulson	do	do	do	do	June 15	Nov. 1	Clay...	415 21.05	18.40	87.4		es apart. Unmanured.
6	Dr. E. F. Russell.	Poynette	Columbia...	Florimond.	Wisconsin Experiment Station.	June 4	Oct. 3	Heavy clay...	265 22.15	18.79	84.9		Do.
7	do	do	do	do	do	June 5	Sept. 30	Prairie...	924 15.40	11.68	75.8		Do.
8	do	do	do	do	do	June 7	Oct. 1	Sandy loam...	321 15.52	9.97	64.2		Do.
9	do	do	do	do	do	June 5	Sept. 30	Prairie...	669 16.20	13.00	80.1		Do.
10	W. R. Chipman	Leeds Center...	do	do	do	May 31	Oct. 27	Black loam...	853 15.85	10.95	69.1		Do.
11	do	do	do	do	do	May 31	Oct. 27	do	1, 833 15.85	12.59	81.4		Barnyard manure.
12	D. L. Cuff	Rocky Run...	do	do	do	May 31	Oct. 13	Sandy loam...	867 16.20	12.86	79.5		Unmanured.
13	H. P. Johnson...	Columbus...	do	Vilmorin	do	June 1	Nov. 1	Clayey...	1, 729 16.32	11.39	74.9		Do.
14	Wm. Strheim	do	do	Unknown	do	June 1	Nov. 1	Black loam...	1, 040 17.89	14.74	82.8		Do.
15	R. K. Beecham.	Sun Prairie	Dane	do	Jas. Vick, Rochester, N. Y.	June 1	Oct. 10	Puttor heavy clay.	2, 524 15.05	10.93	72.7		Do.
16	do	do	do	do	do	June 1	Oct. 10	do	1, 415 11.95	8.26	70.9		Do.
17	Leslie Wright...	Danville...	Dodge	Vilmorin	Wisconsin Experiment Station.	May 28	Oct. 13	Yellow sandy loam.	1, 224 11.05	8.18	74.0		Do.
18	F. C. Cooper	do	do	do	do	May 29	Oct. 13	Yellow clay loam.	1, 622 12.88	8.84	70.8		Unmanured.
19	John Weston	Burnett...	do	Florimond	do	May 30	Oct. 29	Black loam...	1, 609 15.38	12.13	79.5		Unmanured.
20	Aug. Wolnowsky.	Menomonie	Dunn	White Imperial	John Salzer, La Crosse, Wis.	May 30	Oct. 10	Sandy loam...	298 15.05	11.07	73.6		Barnyard manure.
21	Aug. Peter...	do	do	do	do	May 17	Oct. 11	do	866 12.94	9.45	73.0		Unmanured.
22	Sam. Welke	Fall Creek...	Eau Claire	do	do	May 5	Oct. 20	Fine sandy loam mixed with clay.	643 15.86	12.56	79.2		Do.
23	H. D. Hitt.	Oakfield	Fond du Lac	Florimond	Wisconsin Experiment Station.	May 29	Oct. 2	Heavy clayed loam.	1, 011 12.48	7.91	63.4		Barnyard manure.
24	Wm. Merrell	Oak Centre	do	Globe Sugar.	Bryce & Furge-son, Waupaca.	May 30	Oct. 28	Clay loam...	850 17.19	12.84	74.7		Do.
									1, 283 11.42	7.89	69.1		Raised for stock.

Sugar beets in Wisconsin, season 1890, arranged alphabetically according to counties—Continued.

Number.	Name of grower.	Post-office.	County.	Variety.	Seed obtained from—	Time of planting	Time of harvesting.	Soil.	Average weight of beets.	Sugar in juice.	Purity coefficient.	Remarks.
25	John H. Wise	Platteville	Grant	Florimond	Wisconsin Experiment Station.	May 21	Oct. 20	Black loam	719 14.43	10.16	70.3	Barnyard manure.
26	do	do	do	do	do	June 9	Oct. 20	Newly broken timber soil	966 10.92	6.48	59.3	Unmanured.
27	do	do	do	do	do	June 2	Oct. 20	Black loam	1,435 11.42	6.82	59.7	Do.
28	Geo. M. Thomas	Mineral Point	Iowa	do	do	June 12	Oct. 16	Black soil	620 16.78	13.19	78.6	Do.
29	do	do	do	do	do	June 12	Oct. 16	do	650 15.63	12.30	80.6	Do.
30	Geo. E. Kelly	do	do	do	do	May 24	Nov. 1	Clay	590 15.62	11.98	76.7	Do.
31	do	do	do	do	do	May 24	Nov. 1	Garden soil	838 15.40	11.52	74.8	Barnyard manure.
32	R. Crossfield	Fort Atkinson	Jefferson	Vilmorin	do	May 29	Oct. 1	Clay loam	498 16.90	12.94	76.6	Unmanured.
33	Niles Deforest	do	do	do	do	June 1	Oct. 1	do	471 16.41	12.94	78.8	Do.
34	John B. Millard	Lake Mills	do	do	do	June 1	Oct. 20	Heavy dark loam.	839 18.60	13.94	74.9	Do.
35	do	do	do	do	do	June 1	Oct. 20	Red clay	1,285 16.90	13.48	79.7	Do.
36	Geo. W. Kindlin	Fort Atkinson	do	Florimond	do	May 30	Oct. 6	Sandy loam	527 16.32	12.78	78.3	Barnyard manure.
37	Hon. F. A. Hoffmann	Jefferson	do	Vilmorin	Vaughan, Chicago	Apr. 29	Oct. 2	Rich clay loam	1,085 15.51	11.55	74.5	Do.
38	do	do	do	do	do	Apr. 29	Oct. 2	do	1,484 14.59	10.98	75.8	Do.
39	Peter Benz	Kewanee	do	do	do	Sept. 24	Sept. 21	Heavy clay	1,206 17.70	13.96	78.9	Do.
40	Frank Paula	do	do	Bohemian	Imported	Sept. 21	Sept. 24	do	764 10.91	7.63	69.3	Do.
41	Joseph Jeteck	do	do	do	do	Sept. 21	Sept. 24	Black clay soil	835 15.51	12.53	80.8	Do.
42	Peter Benz	do	do	Vilmorin	do	do	do	do	800 19.95	16.38	82.1	Do.
43	Joseph Jeteck	do	do	Bohemian	do	do	do	do	918 18.38	14.80	80.5	Do.
44	Mates Plouhar	do	do	Klein Wanzleben	Imported	do	do	do	496 18.82	16.29	86.6	Do.
45	Frank Albrecht	do	do	do	do	do	do	do	691 17.70	14.72	83.2	Do.
46	Anton Galenberger	do	do	do	Imported	do	do	do	743 16.90	13.26	78.5	Do.
47	W. Holzb	do	do	K. P.	do	do	do	do	522 18.70	16.78	89.7	Do.
48	A. Mattik	do	do	Bohemian	do	do	do	do	1,115 15.05	12.55	83.4	Do.
49	F. Koimek	do	do	Desprez	do	do	do	do	870 16.55	13.76	83.2	Do.
50	Rev. Bergholz	do	do	Unknown	do	do	do	do	1,480 14.25	9.98	69.4	Do.
51	John Jelineck, Jr.	do	do	do	U. S. Department of Agriculture	May 20	Oct. 10	Sandy loam	960 21.40	17.23	80.6	Barnyard manure.
52	Math. Wochoa	Stangelville	do	Desprez Richest	do	do	do	do	856 20.18	17.31	85.8	Do.
53	John Dawson	La Crosse	do	Unknown	Jos. Harris, Rochester, N. Y.	May 7	Nov. 5	Clay loam	1,531 13.18	9.85	74.7	Do.
54	Thomas Mohr	Manitowoc	do	do	A. Landreth, Manitowoc.	May 15	Oct. 10	Black loam	663 18.70	15.24	81.5	Do.
55	do	do	do	do	do	May 15	Oct. 10	do	936 16.65	13.46	80.8	Do.
56	A. Lindner	Kiel	do	do	do	May 15	Oct. 10	do	1,505 15.80	11.22	72.4	Do.

57	Fred. Burrow.....	West Granville...	Milwaukee...	Imperial.....	Erfurt, Germany..	June 10	Oct. 25	Clay.....	91418, 6016 09 86.5	Barnyard ma- nure.
58	do.....	do.....	do.....	Mangold.....	do.....	June 10	Oct. 25	do.....	95318, 6016 33 87.8	Do.
59	G. H. Rawson.....	Oak Creek.....	do.....	Lemnaire's.....	Wisconsin Exper- iment Station.	June 1	Nov. 3	Black sandy loam.	91718, 0215 33 85.1	Unmanured.
60	Julius Roebel.....	West Granville...	do.....	do.....	U. S. Department Agriculture.	May 20	Oct. 28	Black loam...	82419, 2817 08 88.6	Do.
61	do.....	do.....	do.....	Florimond.....	J. Vick, Roches- ter, N. Y.	May 20	Oct. 28	do.....	84418, 9516 10 84.9	Unmanured.
62	S. Wehrmann.....	Binghamton.....	Outagamie.....	do.....	do.....	May 15	Oct. 15	Black clayey...	1,48217, 1212 90 75.4	Unmanured.
63	E. Barkhausen.....	Thiensville.....	Ozaukee.....	Lemnaire's.....	Wisconsin Exper- iment Station.	May 1	Oct. 19	Black sandy loam.	38214, 0010 98 78.5	Unmanured.
64	H. Wehmhoff.....	Burlington.....	Racine.....	Vilmorin.....	do.....	May 31	Oct. 9	Black sandy...	86617, 2213 80 80.5	Sheep manure.
65	F. E. Carewell.....	Lone Rock.....	Richland.....	do.....	Wisconsin Exper- iment Station.	June 7	Oct. 3	Sandy clay...	2,63310, 99 6 43 59.2	Unmanured.
66	E. G. Snyder.....	Clinton.....	Rock.....	Vilmorin.....	do.....	June 1	Oct. 18	Black loam...	38418, 6015 17 81.5	Unmanured.
67	P. F. Newell.....	Jewett Mills.....	St. Croix.....	do.....	do.....	June 1	Oct. 18	Black loam...	43618, 7014 37 76.9	Barnyard ma- nure.
68	M. E. Seymour.....	Reedsburgh.....	Sauk.....	Lane's Imperial..	U. S. Department Agriculture.	May 15	Oct. 16	do.....	1,35810, 1 6 39 03.3	Unmanured.
69	J. W. Wood.....	Baraboo.....	do.....	Florimond.....	Wisconsin Exper- iment Station.	May 24	Oct. 3	Clay loam....	81114, 7010 92 74.3	Barnyard ma- nure.
70	A. E. Marker.....	Reedsburgh.....	do.....	French White Sugar.	T. D. Ferry & Co., Detroit, Mich.	May 15	Oct. 15	Sandy loam...	1,86412, 95 8 88 68.5	Do.
71	E. A. Dwinnell....	North Freedom...	do.....	Lane's Imperial..	U. S. Department Agriculture.	May 15	Oct. 6	Clay loam....	1,19913, 5510 37 6.5	Unmanured.
72	S. A. McCoy.....	do.....	do.....	Imperial Sugar- beet.	do.....	May 18	Oct. 8	do.....	1,310 12 72 8 69 68.3	Barnyard ma- nure.
73	Louis Ballechmie- det.	Sheboygan Falls...	Sheboygan.....	Simon LeGrand..	do.....	May 18	Oct. 15	Black loam....	998 11 42 8 11 71.0	Unmanured.
74	do.....	do.....	do.....	Lane's Imperial..	D. M. Ferry & Co., Detroit,	May 12	Oct. 12	Sandy loam...	764 11 52 8 58 74.7	Do.
75	do.....	do.....	do.....	Klein-Wanzlebe- net.	U. S. Department Agriculture.	May 18	Oct. 12	Black loam....	542 14 70 11 55 78.6	Do.
76	do.....	do.....	do.....	Vilmorin.....	D. M. Ferry & Co., Detroit,	May 18	Oct. 16	do.....	834 14 92 12 27 82.2	Do.
77	do.....	do.....	do.....	French Yellow...	Germany.....	May 20	Oct. 15	do.....	842 11 52 8 08 70.1	Do.
78	A. J. Lamberson...	Whitehall.....	Trempealeau...	Lemnaire's.....	Wisconsin Exper- iment Station.	June 10	Oct. 5	do.....	1,482 16 20 12 39 76.5	Do.
79	Leslie Clark.....	Galesville.....	do.....	Vilmorin.....	do.....	June 8	Oct. 12	Black heavy soil.	770 16 20 12 86 79.4	Horse manure.
80	C. D. Wolfrem.....	West Bend.....	Washington.....	Florimond.....	do.....	May 30	Oct. 7	Hard clay....	823 18 60 15 77 84.7	Unmanured.
81	F. Van Rhenen...	South German- town.	do.....	do.....	Crete, Nebr.	Apr. 28	Sept. 30	Sandy loam...	1,386 17 80 14 74 82.8	Barnyard ma- nure.
82	Mary Henrik.....	do.....	do.....	do.....	do.....	May 15	Oct. 16	do.....	629 17 70 14 58 82.4	Do.
83	John Gebhardt....	do.....	do.....	German Un- known Variety.	Menomonee Falls.	May 15	Oct. 15	do.....	1,040 16 42 13 43 81.9	Do.
84	do.....	do.....	do.....	do.....	do.....	May 15	Oct. 15	do.....	1,017 14 35 11 27 78.5	Do.
85	E. L. Nechs.....	Menomonee Falls.	Waukesha.....	Mangold.....	Germany.....	May 25	Oct. 17	Black loam...	1,039 17 56 14 35 81.7	Unmanured.
86	Mat. Debus.....	do.....	do.....	do.....	do.....	May 25	Oct. 21	do.....	1,350 14 82 11 16 75.3	Do.

Sugar beets in Wisconsin, season 1890, arranged alphabetically according to counties—Continued.

Number.	Name of grower.	Post-office.	County.	Variety.	Seed obtained from—	Time of planting.	Time of harvest- ing.	Soil.	Average weight of beets.	Solids in juice.	Sugar in juice.	Purity coefficient.	Remarks.
87	Mat. Debus.....	Menomonee Falls.	Waukesha....	Vilmorin	Germany	May 25	Oct. 21	Black loam ...	<i>Grams</i> 934	<i>P. ct.</i> 15.75	12.44	78.9	Barnyard manure.
88	...do	...do	...do	Imperial	...do	May 25	Oct. 21	...do	1,323	17.35	14.13	81.4	Do.
89	John Bender.....	Oconomowoc	...do	Lenaire's.....	Wisconsin Experiment Station.	June 5	Oct. 8	Clay loam.....	1,211	17.35	13.85	79.9	Do.
90	Chelsea E. Jones..	North Prairie....	...do	Vilmorin	...do	May 29	Oct. 14	Sandy	1,020	16.20	13.03	80.4	Do.
91	Chas. Churchill...	Waupaca.....	...do	Lenaire's.....	...do	June 1	Oct. 13	Loam	1,031	15.75	12.54	79.6	Unmanured.
92	B. L. Tayler.....	Iola.....	...do	...do	...do	May 10	Oct. 15	Clayey loam ..	1,324	17.35	13.82	79.7	Barnyard manure.
93	R. H. Fisher	Oshkosh.....	Winnebago....	Imperial Sugar ..	Jno. A. Salzer, La Crosse.	May 12	Oct. 31	Black loam.....	875	16.20	12.30	76.0	Do.

The above analyses of sugar beets grown in this State during the last season have a very wide range, viz, from 6.39 to 18.79 per cent of sugar in the juice; of the 95 analyses given in the above table, 19 come below 10 per cent of sugar, 56 come above 12 per cent, 38 above 13 per cent, and 16 above 15 per cent of sugar in the juice. But very few of the farmers who sent in beets for analysis had previously had any experience in growing beets; besides this some of the beets were grown for stock food, with no intention of testing their sugar-producing capacity. Bearing this in mind, it would seem that the showing is a very creditable one; where grown for sugar, and where good care was bestowed, the beets contained a high percentage of sugar. As regards the yield, but very few and uncertain data were obtained, most of the farmers having grown only small plats, from which an estimated yield was reported.

Of the different portions of the State, the eastern region seems better adapted for sugar-beet culture than the western, as far as the data on hand will enable us to judge about the matter. Judging from the data obtained, which are of course very limited, it may further seem that three regions may prove especially well adapted for the culture of sugar beets of the localities from which beets were received during the past season, viz, the country around New Holstein, Calumet County, (latitude about 44°); around South Germantown, Washington County, and around Kewaunee, Kewaunee County (latitude 44.5°). The average of all analyses from New Holstein was found to be the very high figure of 17.83 per cent of sugar in the juice; the average for South Germantown was 13.51 per cent, and for Kewaunee 13.85 per cent (of the fourteen samples received from this locality, twelve came above 12 per cent, and seven above 14 per cent of sugar in the juice). Also other localities may prove well adapted for sugar-beet culture, which have not yet been investigated outside of our substations, *e. g.*, the counties of Rock, Jefferson, Waukesha, Washington, Milwaukee, and Ozaukee, in short the whole eastern portion of the State.

A continued study of this subject may disclose other sections where sugar-beet culture may be conducted successfully. The work has just been entered upon. From what has been done at this experiment station and at substations in different parts of the State, it is known that good crops of beets can be grown of a good quality. While the results reached so far would indicate that Wisconsin may prove well adapted for the culture of sugar beets, the work must be repeated for several seasons before the question can be considered as fully settled.

EXPERIMENTS WITH SUGAR BEETS AT FORT SCOTT, KANSAS.

Quite a number of samples of beets was analyzed at Fort Scott with the following results:

In the juice.

Date.	Total solids.	Sugar.	Purity.	Date.	Total solids.	Sugar.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	
Sept. 26				Nov. 1	15.0	12.2	81.3
Oct. 8	13.13	9.6	73.11	Nov. 1	15.4	12.8	83.1
Oct. 15	15.5	11.5	74.2	Nov. 1	16.8	12.2	72.6
Oct. 18	18.17	13.7	75.4	Nov. 1	15.7	11.7	74.5
Oct. 18	13.84	10.25	74.1	Nov. 1	16.6	13.7	82.5
Oct. 23	13.54	9.5	70.9	Nov. 1	15.7	12.9	82.2
Oct. 23	15.17	12.5	82.4	Nov. 1	19.1	16.7	87.4
Oct. 31	14.85	11.5	77.4	Nov. 1	14.4	11.1	77.7
Nov. 1	15.8	13.25	83.8	Nov. 1	14.0	10.6	75.7

A few of these samples showed good qualities for sugar making, but the most of them had too low a content of sugar and purity to be of any value for the manufacture of sugar.

ANALYSES OF BEETS AT THE AGRICULTURAL DEPARTMENT STATION OF MINNESOTA.

Prof. D. F. Harper, chemist of the station, has furnished me with the following analyses of beets made at that station.

The character of the beets for sugar-making purposes is fairly good:

Varieties.	Brix.	Sugar.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>	
Dippe's Vilmorin	17.10	14.01	81.93
Bult. Desprez's Richest	16.02	14.07	87.89
Simon Legrand's White Improved	17.60	14.83	84.26
Vilmorin's White Improved	15.00	12.17	81.13
Vilmorin	15.95	12.42	77.87
Gregory White Sugar	15.90	12.55	78.93
Lane's Improved	15.86	11.15	73.45
Vilmorin's White Improved	13.72	10.96	79.86
Dippe's Klein-Wanzlebener	15.92	13.04	81.91
Excelsior	15.55	12.26	78.84
Florimond Desprez's Richest	17.24	13.42	77.84
Improved Imperial	14.48	11.45	79.07

EXPERIMENTS WITH SUGAR BEETS AT TOPEKA, KANSAS.

Quite a quantity of beets was brought to the factory at Topeka, and an experimental run was made with them. The number of tons of beets used was 22. The juice from the samples of beets entering the battery was found to contain 15.36 per cent. of total solids and 9.30 per cent. of sugar.

It will be noted by the above figures that the quality of the beets was worthless for sugar-making purposes.

EXPERIMENTS WITH SUGAR BEETS AT MEDICINE LODGE, KANSAS.

In addition to the analyses and control of the sorghum sugar work extensive examinations were made of the beets growing in the locality of Medicine Lodge.

The season was a peculiar one for beets. At the commencement of the rains on the 28th of August the beets were scarcely at all developed and were regarded as a total failure. After the rains commenced the beets grew rapidly and continued to grow vigorously through the months of September and October. About the middle of November the harvesting of the beets was commenced and continued until December. At that time the beets had reached a fair size and developed a high content of sugar. Two hundred and sixty-one wagonloads were brought to the factory and large samples were taken from each of these loads and subjected to analysis. The means of 261 analyses follow :

In the juice.

Total solids.....	per cent..	18.52
Sucrose	do.....	15.12
Purity.....		81.04

Four hundred and eleven miscellaneous analyses of the beets from different plots in the vicinity of Medicine Lodge were made with the following mean results :

In the juice.

Total solids.....	per cent..	17.80
Sucrose	do.....	13.20
Purity.....		75.60

The fresh chips entering the battery had a mean sucrose content in the juice of 13.90 per cent, much less, as will be noted, than that represented by the analyses from the different loads.

The diffusion juices show a content of 10.45 per cent sucrose, and a purity of 81.2.

The working of the beets with the sorghum-sugar machinery was extremely slow, and either from this cause or from the method of liming, which was very heavy without any subsequent use of carbonic acid, the clarification and boiling of the juices became a matter of great difficulty, and they suffered in this process rapid deterioration ; for instance, the purity of the clarified juice was only 78.8 and of the sirup 78.3, while the mean purity of the massecuites showed the enormous depression represented by the difference between 78.8 and 59.4. The actual cause of this remarkable deterioration in boiling is not well understood. The juices boiled with the greatest difficulty, it being almost impossible to prevent them from foaming in the pan. The semi-

sirups also, after standing for a time, deposited a large quantity of mucus or viscous material, and this would lead to the supposition that a pernicious fermentation of a viscous or mannitic nature was the cause of the great loss of sugar during the boiling operations.

It is evident at once that the attempt to make beet sugar without appropriate apparatus must be regarded as futile. Beets of the quality of those delivered at the Medicine Lodge factory, if they had been properly and promptly manufactured, would have yielded almost 250 pounds of sugar to the ton; instead of this the yield was extremely small, the separation from the massecuite very difficult, and the whole manufacturing process disappointing.

In regard to the probability of producing beets in the locality of Medicine Lodge, I am still of the opinion, expressed in Bulletin No. 27, that it is a locality too far south to expect the successful culture of the sugar beet. In using the term "too far south" it is not meant in an absolute sense, but too far south from the zone of the probable beet industry as indicated in the map given in Bulletin No. 27. The actual growing season at Medicine Lodge, it will be noticed, was not during the summer, but in the autumn after the rains fell and the weather had become cool. Had the early part of the season been wet enough to secure a growth of the beets it is hardly probable that they would have shown the high content of sugar which they did. The splendid results obtained at Medicine Lodge in the working of sorghum cane would seem to indicate the course which the sugar industry should follow in that locality. Everything indicates that the culture of sorghum sugar will prove a success while there is little to encourage the further development of the beet-sugar industry in that locality.

ANALYSES OF BEETS AT MEDICINE LODGE.

The following analyses show the character of the beets examined at Medicine Lodge during the months of November and December, 1890. As has been stated, the character of the season at Medicine Lodge was peculiar. On September 25 the beet crop was a total failure. Owing to the extremely dry summer the beets had not grown and were but little larger than a cigar. After that date copious rains with other favorable climatic conditions induced a rapid growth and produced by November a small crop of beets of exceptional richness in respect of sugar content. The data will illustrate in full the character of the juice of the beets. The general data of the season precede the details in the tables.

Analyses of beets—General data.

	Total solids.	Sucrose.	Purity.
Exhausted chips	1.20	.25	-----
Fresh chips	17.31	13.90	80.3
Diffusion juice	12.84	10.45	81.2
Clarified juice	13.65	10.80	78.8
Semi-sirup	43.00	31.95	78.3
Massequite	86.90	51.64	59.4
Marc..... per cent..	5.11	-----	-----
Press cake	-----	1.53	-----
Extraction	-----	98.1	-----
Dilution	-----	27	-----
Sugar	-----	87.0	-----
Beets worked	tons..	293	-----
Harvested	acres..	70	-----

Date.	Fresh chips.			Diffusion juice.			Clarified juice.		
	Solids.	Sucrose.	Purity.	Solids.	Sucrose.	Purity.	Solids.	Sucrose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	
Nov. 23	17.33	13.90	80.37	12.80	9.71	76.02	13.63	9.93	73.02
24	17.03	14.20	83.52	13.03	10.11	79.82	14.07	12.43	*88.43
25	17.62	13.92	79.92	12.67	10.86	85.21	13.24	10.99	82.86
26	17.17	13.70	80.14	12.87	11.03	84.97	13.73	11.37	82.51
28	17.27	12.96	44.98	12.93	11.01	84.83	13.84	11.43	82.60
Dec. 2	18.09	14.11	78.39	11.99	10.22	85.43	14.00	10.67	75.72
3	17.03	13.96	81.81	13.00	10.30	79.11	14.07	10.68	75.69
5	17.00	13.97	81.83	12.97	10.67	82.21	13.82	10.99	78.92
6	17.25	14.38	83.16	13.31	10.14	76.82	12.45	9.38	75.23
Means .	17.31	13.90	80.31	12.84	10.45	81.26	13.65	10.80	78.86

* Sorghum sugar melted in juice.

Date.	Semi-sirup.			Exhausted chips.		Press cake.
	Solids.	Sucrose.	Purity.	Solids.	Sucrose.	Sucrose.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Nov. 23	44.17	32.16	72.91	1.20	.23	1.62
24	46.19	41.19	*89.38	1.32	.30	1.57
25	42.11	29.11	69.98	1.16	.22	1.55
26	43.76	29.16	67.93	1.19	.22	1.42
28	44.11	31.11	70.55	1.27	.24	1.48
Dec. 2	39.24	29.12	74.28	1.22	.26	1.46
3	39.90	29.13	73.00	1.19	.24	1.49
5	42.27	30.11	71.32	1.22	.24	1.64
6	46.00	35.46	77.09	1.16	.30	1.54
Mean ..	43.00	31.95	74.30	1.20	.25	1.53

* Sorghum sugar added.

Date.	Massequite.			Sugar. (sucrose)
	Solids.	Sucrose.	Purity.	
	<i>Per ct.</i>	<i>Per ct.</i>		<i>Per ct.</i>
Dec. 1 ..	87.14	51.02	58.57	86.8
Dec. 8...	86.70	52.26	60.27	87.2
Mean	86.92	51.64	59.42	87.0

Marc..... Per cent. 5.11
 Extraction..... 98.1
 Dilution..... 27.0

Miscellaneous analyses of beets.

[In the juice.]

Date.	Solids.	Sucrose.	Purity.	Description of samples from—
	<i>Per cent.</i>	<i>Per cent.</i>		
July 15	20.50	16.83	82.02	J. H. McCracken.
16	21.53	16.77	76.82	M. Best.
17	21.53	16.54	76.53	Hy. Hinze.
20	19.87	15.75	79.23	P. B. Cole.
24	18.90	15.20	80.43	George Heydenrick.
Aug. 1	14.50	9.45	65.33	Mullen; tops destroyed by web worms.
6	17.73	13.45	73.44	J. H. McCracken.
6	17.03	13.60	80.03	George Mawson.
9	14.20	10.81	76.11	Neligh, Nebraska.
Sept. 1	11.00	7.10	64.14	K. Lammerman.
1	17.10	12.87	74.90	Hy. Hinze.
1	15.63	11.95	76.25	S. B. Hunt; from middle of plot.
1	15.10	15.70	78.75	S. B. Hunt; from outside of plot.
6	15.23	11.14	73.52	Neligh, Nebr.
6	12.13	8.15	66.93	L. Clovis, Wanzlebener.
6	13.03	8.40	64.97	L. Clovis, Vilmorin.
10	15.03	11.25	74.70	George Mawson.
10	13.00	9.25	70.80	M. Best.
10	13.47	9.30	70.10	Do.
10	17.53	13.20	75.42	A. R. Moore.
11	15.83	11.60	73.40	T. Bennings, Wanzlebener.
11	16.00	11.80	73.80	T. Bennings, Vilmorin.
15	12.20	7.90	64.98	K. Lammerman.
15	14.17	11.95	83.39	W. W. S. Snoddy.
15	9.57	7.15	74.73	G. H. Moore.
15	14.17	8.20	58.16	K. Lammerman.
18	16.93	12.55	73.95	A. L. Duncan.
18	15.80	12.00	75.90	John D. Fleming.
18	16.00	11.15	73.62	O. Coyle.
20	13.80	9.45	68.11	W. Helget.
21	17.43	13.05	75.25	A. R. Moore.
23	17.80	11.05	60.72	J. H. McCracken.
25	17.67	9.10	55.02	Osborn.
25	17.37	10.40	60.18	E. Wernet.
25	17.63	9.95	57.69	Dobbs Bros.
25	15.87	8.90	55.39	L. Clovis, Wanzlebener.
25	17.03	9.83	56.86	Do. Vilmorin.
25	16.00	10.95	68.03	Mullen; tops destroyed by web worms.
27	18.37	11.75	63.85	W. Schmidt.
27	18.37	12.65	69.48	A. W. Smith.
27	18.63	12.25	66.30	George Heydenrick.
27	20.30	12.15	59.35	A. R. Moore.
27	18.07	12.60	69.27	Do.
30	17.87	10.95	62.21	C. H. Blackford.
Oct. 1	16.09	11.60	68.78	A. W. Smith.
1	18.10	13.05	72.10	Hy. Hinze.
3	21.43	16.85	78.00	J. H. McCracken.
3	18.63	12.55	67.64	W. Helget.
6	17.20	12.00	69.86	Osborn.
6	19.60	13.45	68.62	Do.
6	17.47	11.20	63.67	T. Bennings, Wanzlebener.
6	17.53	11.70	66.14	T. Bennings, Vilmorin.
6	17.80	10.70	59.92	J. B. Cool.
6	18.60	12.80	67.69	Rice.
6	18.37	13.90	74.01	A. W. Smith; dark ground.
9	17.54	13.60	78.70	O. Coyle; non-alkali soil.
9	15.83	12.05	75.90	O. Coyle; alkali soil.
9	17.80	12.75	71.20	A. L. Duncan.
12	15.10	11.70	78.75	J. H. McCracken.
12	17.37	12.75	73.99	P. B. Cole.
12	19.20	13.60	69.00	M. Best.
12	20.67	15.85	73.76	Do.
15	19.10	12.20	62.03	Hy. Hinze.
15	19.77	14.80	72.21	M. H. Sparks.
15	19.10	12.20	62.03	F. F. Mullen; tops destroyed by web worms.
15	16.87	10.80	63.26	Osborn.
15	16.83	10.55	62.16	J. D. Flemming; average size.
15	16.30	9.90	59.38	J. D. Flemming; large beets.
15	18.37	11.75	64.49	J. D. Flemming; small beets.
15	18.40	10.75	63.39	A. L. Duncan.
15	16.00	11.40	71.88	K. Lammerman.
17	17.83	11.15	63.13	Geo. Heydenrick.
17	18.60	11.75	63.51	Do.
17	18.17	12.15	66.00	W. Schmidt.
17	16.97	10.85	59.56	L. Clovis.
17	15.83	8.75	54.11	Do.
17	20.97	13.20	63.07	A. W. Smith.

Miscellaneous analyses of beets—Continued.

Date.	Solids.	Sucrose.	Purity.	Description of samples from—
	<i>Percent.</i>	<i>Percent.</i>		
Oct. 17.....	19.03	11.50	60.62	T. Bennings.
17.....	19.27	12.55	63.25	Do.
19.....	19.43	11.70	59.95	K. Lammerman.
19.....	17.80	10.70	59.92	Do.
19.....	19.40	11.95	61.31	S. B. Hunt.
19.....	17.67	11.70	66.14	
19.....	15.77	9.80	62.14	Rice.
19.....	17.50	11.20	63.67	Hartzell.
20.....	15.47	9.70	61.40	Dobbs Bros.
22.....	17.07	11.10	63.90	A. R. Moore.
22.....	20.47	11.70	54.66	J. H. McCracken.
22.....	17.67	11.35	64.43	A. R. Moore; roots.
22.....	17.80	10.95	62.21	A. R. Moore; tops of roots above ground.
22.....	18.58	11.70	58.41	O. Coyle.
22.....	20.30	12.15	59.35	J. D. Flemming; roots
22.....	17.57	11.00	62.75	J. D. Flemming; tops of roots above ground.
24.....	19.33	12.30	63.81	W. Welget.
24.....	18.50	11.60	61.44	Blackford.
24.....	19.07	12.25	64.77	F. F. Mullen; tops destroyed by web worms; new tops appeared.
26.....	17.77	10.55	59.30	Underwood.
26.....	18.50	11.85	64.05	P. B. Cole.
26.....	17.30	10.75	62.25	Geo. Mawson.
28.....	19.80	12.75	64.39	J. B. Cool.
28.....	10.03	15.85	83.19	Geo. Heydenrick.
28.....	10.09	12.53	64.92	J. H. McCracken.
28.....	19.77	12.90	65.66	Do.
28.....	18.67	11.40	61.72	K. Lammerman.
28.....	17.43	11.25	64.88	Do.
28.....	16.93	12.50	73.95	M. H. Sparks.
28.....	19.63	13.95	71.98	Hy. Hinze.
29.....	17.57	11.30	62.97	E. Wennet.
29.....	18.43	11.25	61.61	Do.
29.....	18.37	11.40	62.06	S. B. Hunt.
29.....	19.83	12.80	64.55	Dobbs Bros.
29.....	16.17	8.90	51.94	G. H. Moore.
29.....	19.78	13.05	63.95	Dobbs Bros.
30.....	18.46	11.90	64.69	Hartzell.
30.....	17.27	11.50	68.81	Do.
30.....	19.47	13.70	70.42	Blackford.
30.....	18.47	13.43	72.82	Do.
31.....	17.87	12.20	67.71	L. Clovis.
31.....	18.37	12.30	66.96	Do.
31.....	21.18	15.80	74.59	W. Helget.
31.....	19.33	12.80	66.22	P. B. Cole.
31.....	18.89	13.85	73.05	J. H. McCracken.
Nov. 1.....	19.47	14.20	73.70	O. Coyle.
1.....	19.47	13.70	70.42	J. H. McCracken.
2.....	17.47	13.75	78.73	M. Best.
2.....	19.19	13.35	69.56	Do.
2.....	19.88	13.95	71.98	Do.
3.....	19.86	14.25	71.38	Osborn.
5.....	19.40	14.40	74.23	Rice.
6.....	20.07	14.45	72.00	A. W. Smith.
6.....	19.97	15.55	77.76	Do.
6.....	21.00	15.75	75.00	W. Schmidt.
6.....	20.17	14.75	73.12	S. B. Hunt.
6.....	18.78	13.55	72.15	T. Bennings.
7.....	20.02	14.55	72.67	Do.
7.....	21.74	16.15	74.29	Geo. Heydenrick.
8.....	18.97	13.65	73.01	E. Wennet, tops.
8.....	19.27	14.55	75.50	E. Wennet, roots.
8.....	17.43	13.05	75.55	A. L. Duncan.
8.....	19.81	16.20	81.79	Do.
9.....	22.37	17.95	80.63	O. Coyle.
9.....	21.20	17.10	80.66	Do.
9.....	20.83	16.70	80.19	Do.
9.....	16.97	12.55	73.98	Scott Cummings, Canema, Kansas.
10.....	20.23	16.20	80.19	Mawson.
10.....	18.57	13.55	72.97	P. B. Call.
10.....	19.03	15.50	81.60	O. Coyle.
11.....	19.90	16.05	80.69	Do.
12.....	19.53	14.60	74.87	J. H. McCracken.
12.....	21.13	17.50	82.94	O. Coyle.
12.....	17.77	13.40	75.90	M. Best.
12.....	20.63	16.00	77.76	F. F. Mullen; had been injured by web worms; new tops have appeared.
12.....	18.07	15.00	83.30	Do.
12.....	20.00	15.80	79.00	A. L. Duncan.

Miscellaneous analyses of beets—Continued.

Date.	Solids.	Sucrose.	Purity.	Description of samples from—
	<i>Per cent.</i>	<i>Per cent.</i>		
Nov. 12.....	20.70	15.35	74.10	O. Coyle; non-alkali soil.
12.....	15.80	12.00	75.90	O. Coyle; alkali soil.
12.....	17.80	12.75	71.28	Do.
12.....	17.93	14.70	82.10	O. Coyle; non-alkali soil.
12.....	19.60	13.65	76.45	Hunt.
13.....	19.63	15.90	81.12	Smith.
13.....	21.20	17.10	80.66	Do.
13.....	18.93	14.00	74.09	Rice.
13.....	20.23	16.95	83.91	Schmidt.
13.....	19.77	16.17	81.73	Do.
13.....	16.69	12.55	74.00	K. Lammerman.
14.....	19.47	14.65	75.26	J. H. McCracken.
14.....	20.83	16.45	79.09	Mullen.
14.....	18.77	14.30	74.87	Hy. Hinze.
14.....	19.53	14.60	74.87	M. Best.
14.....	19.83	15.25	76.76	Geo. Heydenrick.
14.....	20.40	15.80	78.30	Do.
14.....	18.73	14.40	77.00	P. B. Cole.
14.....	19.67	14.00	74.30	Mullen.
14.....	20.80	16.15	77.64	A. W. Smith, roots.
14.....	19.80	15.40	77.80	A. W. Smith, tops.
16.....	21.20	16.75	79.01	George Mawson.
16.....	15.47	11.90	77.90	K. Lammerman.
16.....	17.77	13.20	74.60	T. Bennings, Wanzlebener.
16.....	18.53	13.80	74.60	T. Bennings, Vilmorin.
17.....	18.59	14.30	78.40	Rice.
17.....	19.87	16.00	80.80	J. B. Cool, roots.
17.....	18.77	14.55	77.50	J. B. Cool, tops.
17.....	21.20	17.10	80.66	J. D. Fleming.
17.....	20.83	16.40	78.44	Do.
17.....	21.27	18.45	87.02	O. Coyle, non-alkali.
17.....	18.89	14.45	76.60	O. Coyle, alkali.
17.....	20.93	16.50	79.09	Beet pile.
17.....	15.10	11.70	78.75	K. Lammerman.
17.....	17.07	15.35	78.25	Beet pile, roots.
17.....	19.00	14.70	78.30	Beet pile, tops to above.
17.....	17.54	13.75	78.73	K. Lammerman.
17.....	18.03	14.10	78.35	Underwood.
18.....	17.47	13.75	78.75	Horn.
18.....	15.65	11.95	76.25	Beet pile, one yellow beet.
18.....	17.40	13.65	78.25	Beet pile, one very large beet, weight 7½ lbs.
18.....	16.93	12.55	73.95	Rice.
18.....	18.77	15.40	82.40	A. W. Smith.
18.....	19.50	16.00	82.01	Do.
18.....	19.60	15.90	81.04	W. Schmidt.
18.....	17.82	13.65	76.45	Hy. Hinze.
18.....	18.27	13.50	74.18	A. R. Moore.
18.....	20.84	15.30	73.40	Do.
18.....	21.84	15.90	72.81	Blackford.
19.....	19.86	14.25	71.38	Osborn.
19.....	20.03	15.00	74.88	Beet pile, well shaped beets.
19.....	20.23	15.40	76.62	Beet pile, well shaped beets.
19.....	20.37	15.35	74.72	Beet pile, well shaped beets.
19.....	17.07	13.35	78.35	Beet pile, imperfect beets.
19.....	20.71	15.35	74.01	O. Coyle.
19.....	19.10	15.90	83.20	Do.
19.....	19.10	14.70	76.20	A. R. Moore.
19.....	19.77	15.60	49.20	J. D. Fleming.
19.....	18.21	15.90	83.90	Do.
19.....	21.73	17.25	80.00	W. Helget.
20.....	20.27	15.90	79.20	Beet pile, selected.
20.....	19.70	15.65	79.20	Beet pile, selected.
20.....	20.83	16.70	83.29	Geo. Heydenrick, selected.
20.....	21.77	17.65	81.33	A. W. Smith, selected.
21.....	17.80	12.75	71.28	Attica, Harper County, Kans.
21.....	17.36	11.25	68.40	Do.
21.....	21.33	16.70	78.40	O. Coyle, non-alkali soil.
21.....	19.23	14.40	75.00	O. Coyle, alkali soil.
21.....	17.77	13.90	78.53	Rice.
21.....	16.67	12.55	74.10	M. Best.
21.....	18.77	14.55	77.50	S. B. Hunt.
22.....	19.63	15.90	81.12	E. Wennet.
22.....	18.33	14.05	77.03	Do.
22.....	18.59	13.55	72.97	Hy. Hinze.
22.....	18.73	13.65	72.73	M. H. Sparks.
22.....	20.23	16.20	80.19	A. L. Duncan.
22.....	18.93	14.00	74.00	J. H. McCracken.
22.....	19.47	14.10	72.70	Do.
22.....	19.77	15.60	79.20	L. Clovis.

Miscellaneous analyses of beets—Continued.

Date.	Solids.	Sucrose.	Purity.	Description of samples from—
	<i>Per cent.</i>	<i>Per cent.</i>		
Nov. 22.....	20.93	16.50	79.00	Do.
22.....	18.89	14.45	76.60	Dobbs Bros.
22.....	21.27	18.45	87.02	A. W. Smith.
22.....	20.83	16.40	78.84	J. D. Fleming.
22.....	21.20	17.10	80.66	O. Coyle, non-alkali.
22.....	17.77	13.85	78.00	G. H. Moore.
22.....	18.07	14.10	78.35	Underwood.
22.....	18.33	14.60	79.80	Beet pile.
22.....	20.60	16.65	80.82	Do.
22.....	19.13	15.00	78.50	Do.
22.....	17.73	13.45	73.44	Do.
22.....	20.29	15.60	76.85	J. B. Cool.
22.....	18.70	13.80	73.79	Do.
22.....	22.00	16.80	76.36	Do.
22.....	19.00	14.90	78.40	Geo. Heydenrick.
22.....	18.27	13.50	74.18	T. Benning, large beets.
22.....	17.82	13.65	76.45	Do. do.
22.....	19.60	15.90	81.04	A. R. Moore, large beets.
22.....	19.50	16.00	82.01	A. R. Moore, small beets.
22.....	18.77	15.40	82.40	Mullen.
22.....	16.93	12.55	73.95	Mullen, very large beets.
23.....	17.40	13.65	78.25	Load, roots.
23.....	15.63	11.95	76.25	Load, top of root.
23.....	19.47	14.65	75.26	Do.
23.....	20.83	16.25	79.09	Load, root.
23.....	19.83	15.45	76.76	Do.
23.....	19.53	14.60	74.87	Load top of root.
23.....	18.77	14.30	76.45	Beet pile, large yellow beet.
24.....	20.93	16.40	78.00	O. Coyle, non-alkali soil.
24.....	19.70	15.65	79.20	O. Coyle, alkali soil.
24.....	20.40	15.80	78.30	J. D. Fleming.
24.....	20.30	15.00	78.70	Do.
24.....	19.00	14.25	75.25	Blackford.
24.....	20.80	16.15	77.64	E. Wenneit.
24.....	21.77	17.65	81.33	W. Helget.
24.....	19.67	14.60	74.50	A. W. Smith.
24.....	20.17	15.55	77.60	A. R. Moore.
24.....	19.57	14.83	76.38	Mullen, roots.
24.....	18.23	14.00	76.90	Mullen, top of root.
24.....	19.33	14.80	76.70	J. H. McCracken.
25.....	20.83	16.70	80.29	Mr. Hinman, taken from pile.
25.....	18.70	14.05	74.88	Osborn.
25.....	21.70	17.40	81.31	W. Schmidt, high, red ground.
25.....	18.63	13.40	73.80	W. Schmidt, low, dark ground.
25.....	21.43	16.80	78.02	Hartzell, dark loam.
25.....	18.33	14.60	79.80	Selected samples, beet pile, roots.
25.....	17.77	13.45	73.44	Selected samples, beet pile, tops.
25.....	22.00	16.80	76.36	Selected samples, beet pile, roots.
25.....	20.29	15.60	76.85	Selected samples, beet pile, tops.
25.....	17.40	13.65	78.25	Selected samples, beet pile, roots.
25.....	15.63	11.95	76.25	Selected samples, beet pile, tops.
25.....	18.51	14.45	77.80	Selected samples, beet pile, roots.
25.....	17.69	13.25	71.26	Selected samples, beet pile, tops.
25.....	17.77	13.80	78.00	Selected samples, beet pile, roots.
25.....	15.88	12.00	78.00	Selected samples, beet pile, tops.
25.....	19.27	16.20	84.07	Selected samples, beet pile, roots.
25.....	20.70	15.35	74.01	Selected samples, beet pile, tops.
25.....	18.13	13.65	74.20	One large beet, A. W. Smith, weight 2 pounds 10 ounces.
26.....	17.80	12.75	71.28	Red and pink beets, pile.
26.....	20.93	17.35	82.81	Selected samples, pile, average weight 9 ounces.
26.....	19.63	15.90	81.12	Selected samples, pile, average weight 13 ounces.
26.....	19.77	15.60	79.20	Transplanted beets, Coyle.
26.....	21.17	16.70	79.14	Selected samples, load of Coyle.
26.....	21.57	17.25	80.23	Do.
26.....	18.83	16.15	85.90	Do.
26.....	21.23	18.35	86.93	Do.
26.....	22.22	16.10	72.49	Do.
26.....	21.12	13.50	63.91	Yellow beets, pile.
26.....	20.87	15.20	72.83	Mawson.
26.....	19.13	14.70	76.95	McCracken.
26.....	10.03	5.60	55.83	White table beet.
26.....	19.70	15.65	79.20	Pile, root.
26.....	18.73	14.40	77.00	Pile, top.
26.....	21.13	17.50	82.94	Pile, root.
26.....	20.40	16.35	80.14	Pile, top.
26.....	17.77	13.80	78.00	Pile, root.

Miscellaneous analyses of beets—Continued.

Date.	Solids.	Sucrose.	Purity.	Description of samples from—
	<i>Per cent.</i>	<i>Per cent.</i>		
Nov. 26.....	17.10	12.87	74.90	Pile, top.
26.....	19.73	16.10	81.63	Pile, root.
26.....	18.77	15.40	82.01	Pile, top.
26.....	20.23	17.00	84.20	Very perfect beets, pile.
26.....	20.65	16.85	81.77	Do.
26.....	21.33	17.00	79.40	Do.
27.....	22.00	16.05	72.95	Load, root.
27.....	19.51	14.60	74.87	Load, top.
27.....	19.47	14.10	72.70	Do.
27.....	21.80	16.05	73.62	Load, root.
27.....	18.89	14.45	76.60	Load, top.
27.....	18.97	15.03	79.40	Load, root.
27.....	18.57	14.50	78.40	Load, top.
27.....	19.90	15.70	79.30	Load, root.
27.....	17.77	13.20	74.60	Jackson.
28.....	22.76	18.50	81.50	Load, root.
28.....	21.63	17.45	80.60	Load, top.
28.....	19.81	16.20	81.79	Load, root.
28.....	19.70	15.65	79.73	Load, top.
28.....	18.03	15.00	83.30	Load, root.
28.....	18.20	14.15	77.98	Load, top.
28.....	18.03	15.00	83.30	Load, tops of root.
28.....	18.37	14.60	79.81	Load, roots.
28.....	21.07	18.40	87.62	Load, tops of root.
28.....	21.77	17.25	79.32	Load, roots.
29.....	20.03	15.80	78.88	Carload of beets from Newton, Kans.
29.....	13.63	8.10	59.69	Do.
29.....	19.69	16.70	83.40	Do.
29.....	20.30	16.20	79.89	Do.
29.....	20.40	15.70	77.00	Do.
29.....	18.40	14.20	76.83	Do.
29.....	18.88	14.00	74.03	Do.
29.....	18.30	15.50	84.70	Load, tops of root.
29.....	18.40	13.95	75.55	Load, roots.
29.....	22.37	18.40	82.51	Load, tops of root.
29.....	21.03	16.35	77.87	Load, roots.
29.....	21.60	18.30	84.72	Load, tops of root.
29.....	21.23	16.10	75.94	Load, roots.
30.....	20.13	16.40	81.60	Beet pile.
30.....	20.80	16.80	80.83	Do.
30.....	19.28	15.35	78.63	Do.
30.....	20.43	17.00	83.33	Do.
30.....	19.27	15.20	79.21	Do.
30.....	20.70	16.70	80.67	Do.
30.....	20.57	16.75	81.43	Do.
30.....	18.20	14.30	78.61	Do.
30.....	21.48	16.90	78.94	Do.
30.....	20.20	17.10	84.60	Do.
Dec. 1.....	13.70	8.60	62.77	Carload of beets from Newton, Kans.
1.....	15.03	9.80	65.33	Do.
1.....	15.03	10.60	70.66	Do.
1.....	15.47	10.60	68.83	Do.
1.....	15.60	9.20	59.00	Do.
1.....	16.43	12.40	75.60	Do.
1.....	13.47	8.60	64.19	Do.
1.....	14.35	10.00	69.09	Do.
1.....	16.10	11.60	72.05	Do.
1.....	15.57	10.80	69.23	Do.
1.....	18.77	13.65	72.73	Beet pile, root.
1.....	17.49	12.37	71.26	Beet pile, top of root.
1.....	19.37	15.40	80.30	Beet pile, root.
1.....	18.80	14.40	77.10	Beet pile, top of root.
2.....	20.83	16.73	80.32	Beet pile, root.
2.....	18.73	14.05	74.87	Beet pile, top of root.
2.....	19.90	15.05	78.31	Beet pile, root.
2.....	18.30	14.25	78.09	Beet pile, top of root.
2.....	19.73	15.60	79.11	Beet pile, root.
2.....	18.73	14.45	77.03	Beet pile, top of root.
4.....	23.07	19.30	83.91	Hartzell. Purchased by Department of Agriculture for seed.
5.....	23.00	18.65	81.32	Do.
5.....	25.27	20.79	83.79	Do.
6.....	23.40	19.45	82.70	Do.
6.....	22.37	17.95	80.58	Do.
6.....	25.83	21.80	80.62	Do.
Mean.....	18.92	15.19	79.83	
Maximum..	25.83	21.80	86.90	
Minimum..	11.27	5.60	54.11	

Load tests.

[In the juice.]

Date.	Solids.	Sucrose.	Purity.	Date.	Solids.	Sucrose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	
Nov. 14.....	17.77	13.85	78.00	Nov. 19.....	15.83	11.60	73.40
15.....	18.07	14.10	78.25	19.....	15.47	12.40	80.50
17.....	18.33	14.60	79.80	19.....	17.80	13.40	75.20
17.....	20.60	16.65	80.82	19.....	17.80	13.45	75.35
17.....	19.13	15.00	78.50	19.....	20.63	16.00	77.76
17.....	17.73	13.45	75.44	19.....	19.67	15.00	76.53
17.....	20.29	15.60	76.85	19.....	19.51	14.60	74.84
17.....	18.70	13.80	73.79	19.....	19.71	15.37	77.40
17.....	22.00	16.80	76.36	19.....	17.38	12.40	71.68
17.....	19.60	14.90	78.40	19.....	18.29	14.00	76.90
17.....	18.27	13.50	74.18	19.....	16.73	12.25	73.65
17.....	17.82	13.65	76.45	19.....	19.63	15.20	77.60
17.....	19.00	15.90	81.04	19.....	19.63	15.00	76.53
17.....	19.50	16.00	82.01	19.....	20.33	16.65	81.89
17.....	18.77	15.40	82.40	19.....	17.50	13.00	74.30
17.....	16.93	12.55	73.95	19.....	17.40	12.75	73.99
17.....	17.40	13.65	78.25	19.....	17.77	13.40	75.70
17.....	15.63	11.95	76.25	19.....	18.17	13.65	75.10
17.....	19.73	16.10	81.63	19.....	16.93	12.65	71.31
17.....	16.60	13.05	78.30	19.....	15.03	11.25	74.70
17.....	17.93	14.70	82.10	20.....	18.30	14.15	77.05
18.....	18.21	15.70	86.25	20.....	19.77	14.90	75.66
18.....	19.30	15.60	80.80	20.....	21.03	16.15	76.79
18.....	20.93	17.25	82.89	20.....	18.77	14.05	74.98
18.....	20.39	16.25	79.69	20.....	18.51	14.35	77.30
18.....	19.90	16.15	81.15	20.....	19.11	15.00	78.50
18.....	19.38	16.90	87.20	20.....	19.00	14.50	76.30
18.....	19.10	14.70	76.95	20.....	20.27	16.20	79.92
18.....	21.50	16.40	76.28	20.....	17.03	12.35	72.35
18.....	17.69	13.30	75.55	20.....	18.27	13.60	74.73
18.....	18.21	14.75	80.80	20.....	17.80	12.70	71.28
18.....	17.77	14.30	88.18	20.....	17.50	14.20	81.10
18.....	17.80	12.75	71.28	20.....	17.80	12.85	71.91
18.....	17.10	12.87	74.90	20.....	17.79	13.25	74.60
18.....	19.63	16.00	81.51	20.....	19.13	14.60	76.40
18.....	19.10	15.90	83.20	20.....	16.53	13.35	80.60
18.....	17.69	13.25	71.26	20.....	20.37	15.60	76.95
18.....	18.51	14.45	77.88	20.....	19.17	15.10	79.05
18.....	19.97	16.00	80.12	20.....	17.67	13.40	76.10
18.....	15.80	12.00	75.90	20.....	19.63	15.25	77.60
18.....	17.77	13.80	78.00	20.....	19.93	15.00	75.50
18.....	18.33	14.60	79.80	20.....	19.77	15.10	76.44
18.....	18.33	14.20	77.60	20.....	18.80	14.35	76.05
18.....	18.57	14.55	78.40	20.....	16.00	12.15	75.65
18.....	20.70	15.35	74.01	20.....	20.40	16.15	79.16
18.....	18.63	14.20	76.30	20.....	19.73	15.25	77.20
18.....	19.27	16.20	84.07	20.....	18.37	14.60	79.80
18.....	17.77	14.70	83.00	20.....	17.53	13.00	74.85
19.....	20.00	15.60	78.00	20.....	20.37	15.35	76.12
19.....	18.03	14.10	78.35	20.....	20.17	16.00	79.32
19.....	17.47	13.75	78.73	20.....	19.03	14.50	76.30
19.....	17.54	13.60	78.70	20.....	17.71	14.95	84.20
19.....	19.00	14.70	78.30	20.....	19.27	15.35	79.20
19.....	17.07	13.35	78.25	20.....	18.00	14.10	78.90
19.....	15.10	11.70	78.75	20.....	17.39	12.50	72.83
19.....	18.27	14.80	81.30	20.....	17.78	14.30	81.40
19.....	20.17	15.20	75.62	20.....	16.41	12.10	73.75
19.....	16.00	11.90	74.35	20.....	19.47	14.20	73.70
19.....	16.00	11.80	73.80	20.....	18.60	14.20	76.30
19.....	16.53	12.15	73.35	20.....	18.40	13.95	75.55
19.....	18.33	14.20	77.60	20.....	19.16	14.55	76.40
19.....	17.53	13.20	75.42	20.....	18.27	14.50	79.70
19.....	17.57	13.20	75.40	20.....	18.43	13.75	75.00
19.....	18.20	14.70	80.80	20.....	18.83	14.00	74.48
19.....	19.37	15.30	79.30	20.....	16.30	12.40	76.10
19.....	19.60	15.70	80.60	21.....	17.27	13.95	81.40
19.....	18.70	15.10	80.70	21.....	19.81	16.20	81.79
19.....	18.30	13.70	85.80	21.....	20.33	15.90	79.31
19.....	13.37	14.95	81.46	21.....	18.80	14.40	77.10
19.....	17.53	13.35	75.00	21.....	19.37	15.40	80.30
19.....	17.40	13.40	77.00	21.....	20.33	16.40	80.67
19.....	19.11	14.60	76.42	21.....	21.00	16.35	77.86
19.....	18.74	14.10	75.60	21.....	20.40	15.70	79.80
19.....	18.03	15.00	83.30	21.....	18.80	14.95	77.80
19.....	18.43	14.00	76.20	21.....	16.80	12.90	77.40
19.....	17.00	13.00	76.50	21.....	18.40	15.10	81.30
19.....	16.93	12.50	73.95	21.....	20.37	15.40	75.87

Load tests—Continued.

[In the juice.]

Date.	Solids.	Sucrose.	Purity.	Date.	Solids.	Sucrose.	Purity.
	<i>Per cent.</i>	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	
Nov. 21.....	21.23	16.10	75.94	Nov. 24.....	20.47	15.25	74.50
21.....	17.47	12.37	71.26	24.....	21.57	17.25	80.23
21.....	18.77	13.65	72.73	24.....	19.63	14.93	76.02
21.....	19.87	15.80	80.30	24.....	19.57	15.20	77.90
21.....	17.43	13.05	75.25	24.....	19.80	15.40	77.80
21.....	19.27	15.10	78.65	24.....	21.20	16.75	79.01
21.....	17.20	14.75	85.45	24.....	19.90	16.05	80.69
21.....	21.80	17.15	78.67	24.....	19.60	16.05	82.00
21.....	18.90	14.00	75.16	24.....	16.40	11.90	73.20
21.....	19.30	14.80	76.70	24.....	15.47	11.90	77.90
21.....	20.00	14.80	74.00	24.....	19.90	15.35	76.88
21.....	19.00	13.70	72.66	24.....	17.77	13.20	74.60
21.....	19.00	14.25	75.25	24.....	18.17	14.15	77.90
21.....	20.80	16.15	77.64	24.....	19.77	16.17	81.73
21.....	21.77	17.65	81.33	24.....	19.57	15.55	79.50
21.....	19.67	14.60	74.50	24.....	19.67	15.40	78.60
21.....	20.17	15.55	77.60	24.....	19.03	15.50	81.60
21.....	19.57	14.85	76.38	24.....	19.93	15.20	76.38
21.....	18.23	14.00	76.90	24.....	18.53	13.80	74.60
21.....	19.33	14.80	76.70	24.....	20.13	16.10	80.19
21.....	20.83	16.70	80.29	24.....	18.83	16.15	85.90
21.....	18.70	14.05	74.88	24.....	19.87	16.00	80.80
21.....	20.00	15.90	79.50	24.....	18.57	14.50	78.40
21.....	20.00	15.45	77.25	24.....	19.87	16.00	80.80
21.....	18.63	14.00	75.27	24.....	20.50	16.15	78.53
21.....	19.03	15.85	83.20	24.....	19.63	15.40	78.60
21.....	18.23	13.75	75.80	24.....	18.70	14.65	78.10
21.....	19.91	14.90	75.20	24.....	19.70	15.40	78.20
21.....	19.49	14.60	74.87	24.....	18.13	14.45	79.60
21.....	19.59	14.60	75.26	24.....	20.23	16.95	83.91
21.....	18.29	14.20	78.00	24.....	21.33	16.70	78.40
21.....	19.89	15.05	78.30	24.....	19.23	14.40	75.00
21.....	21.39	16.25	76.29	24.....	17.77	13.90	78.55
21.....	18.19	14.10	77.90	24.....	16.67	12.55	74.10
21.....	16.63	14.30	86.15	24.....	18.77	14.55	77.50
22.....	20.43	15.50	75.92	24.....	19.63	15.90	81.12
22.....	18.77	14.30	76.45	24.....	18.33	14.05	77.03
22.....	19.03	14.20	74.79	24.....	18.57	13.55	72.99
22.....	21.63	17.40	80.55	24.....	18.73	13.65	72.73
22.....	20.33	15.60	76.85	24.....	20.23	16.20	80.19
22.....	20.33	15.70	77.32	24.....	18.93	14.00	74.09
22.....	20.47	15.25	74.50	24.....	19.47	14.10	72.70
22.....	19.47	14.65	75.26	24.....	19.77	15.60	79.20
22.....	20.83	16.45	79.09	24.....	20.93	16.50	79.00
22.....	19.83	15.25	76.76	24.....	18.89	14.45	76.60
22.....	19.53	14.60	74.87	24.....	21.27	18.45	87.02
22.....	18.77	14.30	76.45	24.....	20.83	16.40	78.84
22.....	20.93	16.40	78.00	24.....	21.20	17.10	80.66
22.....	19.70	15.65	79.20	26.....	20.73	16.60	80.00
22.....	20.40	15.80	78.30	26.....	21.03	18.00	85.71
22.....	20.30	15.00	78.70	27.....	17.83	13.40	75.30
22.....	18.73	14.40	77.00	27.....	21.37	17.90	84.03
22.....	19.90	15.25	76.38	27.....	20.10	16.65	82.83
22.....	19.30	15.90	82.90	27.....	19.00	15.30	81.00
22.....	20.27	15.90	79.20	27.....	22.00	16.05	72.95
22.....	19.70	15.35	77.70	27.....	21.80	16.05	73.62
22.....	21.60	17.20	80.00	27.....	18.97	15.05	79.40
22.....	21.40	17.50	81.77	27.....	19.90	15.70	79.30
22.....	20.90	16.75	80.14	28.....	20.00	15.80	79.00
22.....	10.67	15.60	79.60	28.....	22.76	18.50	81.50
22.....	21.13	17.50	82.94	28.....	19.51	16.20	81.79
22.....	21.13	17.50	82.94	28.....	18.03	15.00	83.30
22.....	19.73	15.00	76.14	28.....	21.07	18.40	87.62
23.....	21.73	17.25	80.00	28.....	24.37	19.50	80.25
23.....	20.40	16.35	80.14	29.....	18.30	15.50	84.70
23.....	21.40	17.40	81.31	29.....	22.37	18.40	82.51
24.....	19.43	16.05	82.22	29.....	22.37	18.40	82.51
24.....	21.17	16.70	79.14	29.....	21.60	18.30	84.72
24.....	19.80	15.45	77.80	Dec. 1.....	18.73	15.50	82.90
24.....	20.43	15.95	78.18				
24.....	16.37	12.95	79.80	Mean.....	18.52	15.12	81.04
24.....	20.20	15.75	78.20	Maxims..	24.37	19.50	88.18
24.....	19.83	15.45	77.80	Minims..	15.10	11.60	71.26
24.....	19.17	14.50	75.91				

Composition of ash of beets grown at Medicine Lodge, Kansas.

DESCRIPTION OF SAMPLES.

No. of sample.	Description.	Grown by—	Kind of soil.
8432	{ Necks of beets { Roots 8433 { Necks of beets { Roots 8434 { Necks of beets { Roots { Leaves	{ Mr. Fleming { O. Coyle { A. W. Smith	Upland red soil. Bottom alkali soil. Bottom land; not alkaline.

Table of analyses of ash of beets and beet leaves, grown at Medicine Lodge, Kansas.

ASH, SOLUBLE IN BOILING WATER.

	Necks of 8432.	Roots of 8432.	Necks of 8433.	Roots of 8433.	Necks of 8434.	Roots of 8434.	Leaves of 8434.
CO ₂	15.50	19.90	22.44	29.04	17.50	27.17	14.34
Cl	17.39	16.37	4.53	2.88	14.25	11.78	17.36
SO ₃	7.76	2.66	10.17	5.02	10.49	1.97	12.72
P ₂ O ₅	1.73	2.74	2.57	0.87	3.03	5.70	0.42
K ₂ O	46.95	45.79	57.52	61.90	51.10	50.30	41.33
Na ₂ O	11.57	13.22	2.87	2.45	6.92	3.05	18.65
SiO ₂	0.88	0.30	0.50	0.30	0.20	0.20	0.35
CaO	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	0.53
Total	101.78	100.98	100.60	102.46	103.49	100.13	105.70
Corrected for Cl	97.86	97.29	99.58	101.59	100.28	97.48	101.77

ASH, INSOLUBLE IN BOILING WATER.

	4.07	6.36	8.28	7.99	6.95	3.95	3.37
CO ₂	4.07	6.36	8.28	7.99	6.95	3.95	3.37
SiO ₂	36.74	19.21	23.56	12.49	35.96	9.31	55.86
Mn ₂ O ₄	1.21	1.31	0.74	1.54	0.74	1.10	0.41
CaO	12.76	13.82	23.24	23.11	11.02	14.82	12.36
P ₂ O ₅	7.66	10.74	14.48	16.03	16.81	20.10	6.59
MgO	22.58	38.27	21.44	37.53	15.51	38.28	15.01
Fe ₂ O ₃	6.70	4.88	4.73	0.76	5.80	4.60	3.40
K ₂ O	5.60	3.30	2.07	1.22	3.05	4.35	3.20
Na ₂ O	2.54	1.50	1.04	0.33	2.25	1.63	1.95
Total	99.86	99.39	99.58	101.00	98.09	98.14	102.15

TOTAL, SOLUBLE AND INSOLUBLE ASH COMBINED,

	12.07	17.19	16.33	23.67	14.07	21.32	9.35
CO ₂	12.07	17.19	16.33	23.67	14.07	21.32	9.35
Cl	12.17	13.05	2.90	2.15	9.60	9.26	9.41
SO ₃	5.43	2.12	6.74	3.74	7.05	1.55	6.89
P ₂ O ₅	3.51	4.36	6.58	4.74	7.52	8.78	3.31
K ₂ O	34.55	37.17	40.21	46.43	35.43	43.97	10.11
Na ₂ O	8.86	10.84	2.25	1.91	5.39	2.95	2.40
SiO ₂	11.64	4.14	8.27	3.48	12.85	2.05	26.14
Mn ₂ O ₄	0.36	0.27	0.25	0.39	0.24	0.24	0.14
CaO	3.83	2.81	7.83	5.89	3.59	3.15	6.03
MgO	6.77	7.77	7.23	9.57	5.48	8.19	7.02
Fe ₂ O ₃	2.01	0.99	1.59	0.19	0.99	0.98	3.18
Total	101.20	100.71	100.18	102.16	102.21	102.44	103.98
Corrected for Cl	98.40	97.77	99.53	101.67	100.04	100.35	101.62

EFFECT OF SOIL ON BEET PRODUCTION.

Not only the climate but also the soil affects profoundly the quality of the beets grown. This is well illustrated by the experiment of Briem, published in *Austro-Hungarian Journal of the Sugar-Beet Industry and of Agriculture*, vol. 17, p. 571.

Briem chose two typical soils for a comparative trial, near each other, in order to secure identical climatic conditions. The mother beet from

which the seeds were obtained was a Vilmorin improved, which contained 19.86 per cent sugar. The seeds were planted in the two soils under precisely similar conditions and received the same culture. The one soil was very poor, with a gravelly subsoil. The other was a rich garden soil, on which a pond had once stood.

The beets which were produced were so different that even an expert would not have admitted that they came from the same seed. The poor soil gave a small beet, which soon reached the term of its vegetation, while the rich soil furnished a beet resembling those raised for forage and which at the time of harvest was still in full vegetation. A tabular view of the results is instructive:

Description.	Weight of root.	Sugar.
	<i>Grams.</i>	<i>Per cent.</i>
Mother beet	298	19. 86
Beet from poor soil	160	14. 57
Beet from rich soil.....	876	13. 61

That a race of beets introduced into a new country develops new characteristics has long been known, but the above shows in a striking manner the part that the soil itself may take in these transformations.

CULTURE OF THE KLEIN WANZLEBENER ORIGINAL.

In a letter from the proprietors of the sugar factory at Klein Wanzleben, some interesting data have been communicated concerning the original Klein Wanzlebener beet, from which all the different varieties of this family have been derived. The methods of selection of beets for seed production are described as follows:

For the production of our beet seed, which is carried on by us exclusively, we use none but the full-grown beets, having never been able to satisfy ourselves with regard to the use of small beets. Although this method of cultivation would be much more profitable it has always appeared to us to be contrary to all laws of nature, and the seed from such imperfect beets is certainly more subject to degeneration than that from full-grown, mature beets. Variations of form can never be safely detected in these dwarf beets, while the mature beets are chosen with the greatest certainty by their external appearance.

The selection of the mother beets on the field and before siloing is made with the greatest care. Only those fields are used for this purpose which have been planted with seed from beets which were polarized and whose actual sugar content has been determined by the alcohol-extraction method. All beets which are defective in growth are rejected.

The process of selection commences in November, after all the beets have been harvested, and continues until the middle of April.

The work is carried on in three laboratories. In Laboratory I the beets are assorted by means of a solution of salt. About nine-tenths of all the beets reserved for seed selection are rejected in this laboratory, and only about 100,000 beets are transferred to Laboratory II.

The per cent of sucrose in the juice of these beets is now determined in Laboratory II by the polariscope, the figure thus obtained being always considerably reduced so as to allow for variations. The actual sucrose content of these polarized beets—daily about 150–200—is determined in Laboratory III by the alcohol method, so as to have a check on the polarization, and to avoid errors which might be caused by the presence of optically active bodies. Only those beets whose high sugar content is definitely proved by the last method are chosen for cultivation. These are again assorted, the finest specimens being planted in the spring for the production of extra fine seed. This seed, of which we can only furnish limited quantities, is therefore obtained from high polarizing beets without an intervening generation. We do not, however, consider that the careful selection of mother beets by their sugar content insures satisfactory results. If the choice of mother beets by polarization were the only condition necessary to obtain good results, every large estate would be able within a few years to raise a beet satisfactory in all respects. This is, however, impossible, as the beet is, more than any other plant, subject to sudden degeneration, which is explained partly by the history of its development and partly by insufficient transmitting of those qualities which distinguished the mother beet.

Very often external conditions, such as location and fertilization, exercise at times a deteriorating influence and cause a poor quality of beet, such as is not a natural variation of the family and is not hereditary.

For these reasons it is absolutely necessary, if we wish to raise a beet of constant high quality, to observe the experimental crops for a number of years, both as to their external appearance and chemical properties.

The fact that the beet is a biennial plant renders this method of selection proportionally more difficult.

The cultivation by families, together with the most conscientious individual cultivation, has been the foundation of our work for more than 30 years. It insures certain success to the growers of our original beet, an individual superior both in quality and quantity; in short, results such as the varieties introduced in Germany during the last ten years are unable to guaranty as the proof of their constant high quality, which can only be determined by careful observations extended over many years, is wanting.

As a transfer of the beet into other conditions of climate and soil may cause a deterioration in the second generation, the statement that the seed was obtained from our finest quality of beet is not a certain guaranty of success.

Some interesting data in regard to the operation of the sugar factory are also communicated, this being one of the companies which carries on both the manufacture of sugar and the production of sugar-beet seed. As will be seen from the data communicated the object is to produce not only a rich beet but one of large size, so as to secure as large a yield as possible of sugar per acre.

The data in regard to the operations of this factory follow :

[Sugar Factory Klein Wanzleben, successors to Rabbethge & Giesecke Stock Company at Klein Wanzleben.]

We beg permission to send the following data for general information concerning our house :

Our capital is 2,700,000 marks. Our stockholders are under no obligations to raise or furnish beets.

Our plant consists of a raw-sugar factory, which diffuses about 7,000 hundred-weight beets per day, and a molasses desucration factory, which is capable of working up about 1,000 hundred-weight of molasses. A large farming estate is connected

with the factory. The beet-sugar factory diffuses during the campaign about 500,000 hundred-weight beets. The yield in the campaign of 1890 was:

	Per cent.
First product	11.32
Second product about	1.40
Third product about	.20
Total	12.92

Our estate consists (excluding a large area which is planted with wheat, oats, etc.) of about 5,000 morgen of beets, both purchased beets and seed beets (4 morgen = 1 hectare; 1 English acre = about $1\frac{1}{2}$ morgen).

The yield of 1889 was reduced by the poor results on certain strips of land, but nevertheless the average yield was 207.4 hundred-weight per morgen, some strips yielding as high as 284 hundred-weight. The crop of 1890 will yield about 200 hundred-weight per morgen.

A very important branch of our farm is the improvement of beet seed, which we have engaged in for the last thirty years.

The mother beets are chosen from the plats by careful methods of selection. In 1889-'90 we examined 2,782,300 beets, of which 3,043, that is, about one per thousand, were chosen for purposes of cultivation. The extensive work of selection occupies our experts from January to April, and visitors to our laboratories are always welcome. We are always pleased to give all information desired.

Our united farming and manufacturing interests soon proved to us the necessity of cultivating beets according to the yield of sugar per morgen, and we found the cultivation of our original Klein Wanzlebener beet, which unites a high yield per morgen with a high sugar content, as most profitable.

We desire to point out that we have adopted the name *Original Klein Wanzlebener beet seed*, as varieties of this beet have appeared of late which are offered under such names as "improved, containing a high percentage of sugar," etc., and which, in many cases, are not equal to the Klein Wanzlebener beet. The above name also provides a means of distinguishing between our original beet and these varieties.

We will be glad to furnish directions for the introduction of the beet, its cultivation, the methods of planting our Original Klein Wanzlebener beet, and samples of the seed.

KLEIN WANZLEBEN, *February*, 1890.

SYSTEMATIC STUDY OF THE DIFFERENT VARIETIES OF SUGAR BEETS IN SAXONY.

Professor Maercker of Halle has, for several years, collated the data in regard to the different varieties of sugar beets grown in Saxony; arranged in respect of their improvement in sugar percentage and in yield of sugar per acre. Nine reports have already been issued on this subject, containing data on all the different varieties of sugar beets grown in Saxony and especially on the different branches of the Vilmorin and Klein-Wanzlebener families of beets.

From Professor Maercker's ninth report the following table has been compiled, showing the character of some of the different varieties of beets investigated :

Comparative mean results of Professor Maercker's experiments in 1888.

	Sugar in the beet.	Sugar in the juice.	Purity quo- tient.	Yield of beets per acre.	Yield of sugar per acre.	No. of beets per acre.
Sugar beets of Vilmorin origin :	<i>Per ct.</i>	<i>Per ct.</i>		<i>Pounds.</i>	<i>Pounds.</i>	
Gehr. Dippe's zuckerreichste Élite.....	15.96	18.15	87.70	25,942	4,141	34,773
Heine-Emersleben verbesserte Vilmorin.....	15.70	17.81	87.70	27,702	4,349	33,894
Schreiber & Sohn Original.....	15.49	17.87	87.10	26,752	4,145	34,461
Knoche-Wallwitz, Vilmorin.....	15.48	17.90	88.23	29,128	4,509	34,677
Mette Vilmorin.....	15.37	17.67	87.80	27,262	4,189	35,254
Strandes Vilmorin.....	15.22	17.37	87.30	25,274	3,846	34,738
Schlittke-Anmühle Vilmorin.....	15.04	17.20	87.40	27,262	4,101	34,253
Grasshoff-Quedlinburg Vilmorin.....	14.82	17.05	88.40	28,019	4,154	34,482
Means	15.39	17.63	87.71	27,174	4,180	34,566
Sugar beets of Klein-Wanzlebener origin :						
Gehr. Dippe's verbesserte Klein-Wanzlebener Élite.....	15.55	17.89	88.75	31,698	4,928	34,909
Knoche-Wallwitz Klein-Wanzlebener.....	15.53	17.48	87.30	31,064	4,822	36,154
Kortum-Sondershausen Klein-Wanzlebener.....	15.44	17.61	88.20	28,670	4,428	34,525
Klein-Wanzlebener Original.....	15.38	17.44	88.73	32,965	5,071	35,163
Heine-Emersleben Klein-Wanzlebener.....	15.36	17.56	88.70	32,102	4,933	35,048
Neu-Querfurter Rübe.....	15.21	17.24	88.80	31,768	4,831	36,059
Grasshoff-Quedlinburg Klein-Wanzlebener.....	14.91	16.71	88.30	29,374	4,379	34,266
Braune-Biendorf Klein-Wanzlebener.....	14.85	17.01	88.10	32,894	4,884	35,446
Schreiber & Sohn Klein-Wanzlebener.....	14.71	16.62	87.80	33,686	4,956	37,200
Rimpau-Schlanstedt Klein-Wanzlebener.....	14.69	16.75	87.60	33,950	4,988	35,222
Wilke-Gr.-Möhlingen Klein-Wanzlebener.....	14.56	16.67	88.20	33,422	4,866	35,170
Ziemann-Quedlinburg Klein-Wanzlebener.....	14.43	16.44	87.80	34,109	4,475	36,133
Strandes-Zehringen Klein-Wanzlebener.....	14.40	16.64	87.40	33,810	4,870	35,971
Means	15.00	17.08	88.13	32,278	4,836	35,482
Sugar beets of other strains :						
Bestehorn-Belitz Dividenden.....	15.15	17.88	87.70	28,670	4,344	34,936
Mette Specialität.....	14.78	16.60	87.70	32,877	4,859	34,955
Braune-Biendorf Kreuzung.....	14.71	16.90	88.04	33,264	4,893	34,912
Schlieckman-Auleben Specialität.....	14.38	16.35	87.80	33,352	4,796	34,349
Means	14.76	16.93	87.81	32,050	4,724	34,787

GENERAL CONCLUSION.

The result of the analyses at Grand Island and other places show that beets of high sugar content and great purity can be grown in many parts of the United States. The average size of the beets, however, in many places is too small to assume that their culture would prove profitable. It would be far better for all interests to grow beets averaging from 600 to 700 grammes in weight, even if the percentage of sugar should drop one or two points. The causes of the small crop at Grand Island have already been set forth, and it is not necessary to repeat them here. The Department has organized an experimental station for the culture of the sugar beet at Schuyler, Nebraska, and it is confidently expected that rich beets with high tonnage can be produced.

In a critical study of the data given above there are many points of interest. In judging of the character of a beet for sugar-making

purposes three factors must be taken into consideration. First of all, the beet must be large enough to make its growth profitable to the farmer. Experience has shown that a beet which weighs about 600 grammes, that is a little over 1 pound, is best suited to secure the interests of both the farmer and the manufacturer. Therefore, in all cases attempts should be made to grow beets as uniformly as possible of that weight. Having once established the average weight of the beet, the next point to be considered is its content in sugar. In the data given the percentage of sugar is reckoned on the weight of the beet itself and not upon the extracted juice. Sugar beets contain on an average about 5 per cent of marc and 95 per cent of juice. Therefore if the analysis is made upon extracted juice, the number obtained must be multiplied by 0.95 to give the percentage of sugar in the beet.

The question may arise as to how poor a beet can be in sugar and still be profitable for sugar making. This of course is a question which has to be determined by a comparison with many economic problems, the study of which can not be introduced at the present time. In general, however, it may be said that the limit of profit in manufacture will be reached when the percentage of sugar in the beet drops to 12, although it is possible under certain conditions for factories to work economically and profitably on beets having a lower percentage of sugar than that indicated.

With the present degree of perfection in the production of rich sugar-beet seed, and with the knowledge of the scientific principles of agriculture which should guide the beet-grower, it is possible, I think, to show that beets can be produced, under favorable soil and climatic conditions, which will contain on an average 14 per cent of sugar. The farmer, therefore, should not be satisfied if his results fall below this standard.

It will be easy to see, by comparing the averages given in the above tables, how many of the beet-growers have succeeded in growing plants which will average 600 grammes in weight and contain 14 per cent of sugar.

In addition to these two factors, however, a third must be taken into consideration, namely, the purity of the juice. By the purity of the juice, or, as it is expressed in the tables, the coefficient of purity, is meant the ratio of pure crystallizable sugar in the juice to the total solids therein. For instance, if in 100 parts of solids there are 80 parts of pure crystallizable sugar, the coefficient of purity of that juice is said to be 80. The number 80 may be taken as a fair average which should be attained in this country. In the older beet-growing countries a much higher degree of purity can be obtained than this. The degree of purity of the juice is influenced chiefly by the amount of salts which are represented in the analysis by the ash obtained on the ignition of the sample. In soils highly impregnated with mineral substances, such as are often found in our western countries, the percentage of ash will be

found very high, and there will be a corresponding depression of the purity coefficient. In lands, however, which have been long cultivated, and scientifically treated from an agricultural point of view, the percentage of ash in the beet will be diminished and the purity coefficient correspondingly raised. The ash of the beet consists largely of phosphoric acid and potash, and these two substances are essential to the proper growth of the beet. It is therefore not expected that the ash of the beet shall be reduced below a certain content, otherwise the growth and maturity of the plant will be retarded. It will not be possible in the space which is at our disposal here to discuss each of the series of data obtained by these analyses, but the above remarks are made for the purpose of enabling anyone who is interested in any particular series or analysis to discuss it intelligently and determine from the numbers given the value of the beets produced for sugar-making purposes. At the present time, for the purpose of fixing a standard of comparison, I would say that the typical sugar beet for sugar-making purposes should weigh 600 grammes, contain 14 per cent of sugar, and have a purity of at least 80. With such raw material at his disposal in sufficient quantity, the manufacturer can not fail of success, provided he be supplied with the latest and most improved forms of machinery.

It may also be of interest in connection with the data above given to discuss some of the particular qualities of the beet separately. In general the mistake is made by those not acquainted with the principles of the growth of the sugar beet and manufacture of beet sugar of judging of the possibilities of success by the percentage of sucrose in the beet alone. The danger of relying solely upon this constituent of the beet is at once manifest from the considerations above mentioned. Nevertheless, as it is often done, I have collected into tabular form from the analyses given all of the sugar beets showing from 15 to 18 per cent of sugar in the juice, which were analyzed by the Department at Washington during the past season. In another table have been collected all the beets in the juice of which more than 18 per cent of sugar was found. In the case of Minnesota 3 samples of beets were found in which the percentage of sugar was more than 18; in the State of Indiana, 1 sample; in Iowa, 1; in North Dakota, 4; in Maryland, 5; in Colorado, 1; in Wyoming, 1; in Nebraska, 13. Of beets showing a percentage of sugar from 15 to 18 in the juice the following numbers of samples were found: In Illinois, 3; in Minnesota, 15; in Nebraska, 36; in Maryland, 8; in Iowa, 4; in Wyoming, 2; in Colorado, 9; in North Dakota, 4; in Massachusetts, 1; in Wisconsin, 2; in California, 2; in South Dakota, 6; in Michigan, 4; in Kansas, 3; in Washington, 1; in Oregon, 2; in Virginia, 2.

The production of beets containing from 15 to 18 per cent of sugar is not unusual, and such beets may be regarded as strictly normal in constitution, but possessing a particularly high content of sugar. When, however, the content of sugar in the beet exceeds 18 per cent

it must be regarded at the present time as something abnormal and due to peculiar conditions affecting the particular locality, or even the particular plant itself. Such beets are usually extremely small in size, and the richness of their sugar content has been acquired at the expense of normal growth. In other cases the effect of a particularly dry season preceding the time of harvest or other very peculiar conditions may affect the sugar content. In many other cases, from the wilted condition in which the beets have been received, it must be admitted that a portion of the water which they contained has dried out between the time of harvest and the time of analysis, thus increasing the apparent percentage of sugar in the beet. It will doubtless be possible hereafter, when the beet has been more fully developed by careful selection, to produce beets normally which contain more than 18 per cent of sugar, but to expect at the present time the production of such beets on a large scale would be unreasonable, and such an expectation would not be realized. Even when we consider the other class, namely, those containing in their juice from 15 to 18 per cent, we must confess that it would be unwise to look for a production of beets on a large scale containing so large a percentage of sugar. In many of the cases of beets of this class the high sugar content must be ascribed primarily to some of the conditions mentioned for the class above 18.

When, however, the tables are further studied, and the remarkably low percentages of sugar are noticed which were sometimes found, it must be confessed that in these cases the abnormally low content of the sugar is also due to the abnormal growth of the beet. In some cases these beets are of abnormal size, weighing 2,000 grammes or over, and to this extraordinary growth must be attributed to a certain extent the low content of sugar. In general, it has been found that when beets exceed 600 grammes in weight it is difficult to maintain their sugar content at a high standard. When, therefore, the beets become immensely overgrown it is always accompanied with a falling off in content of sugar. In the cases, however, of the small beets which have shown a low content of sugar, the result must have been due to defective conditions of soil and climate, or to defective methods of planting and cultivation, or to premature harvesting.

When we consider the varying qualities of beets which have been grown from the same seed, we are at once struck with the immense importance of the factors of soil, climate, and cultivation, in the production of the sugar beet. In the fact that the seed of the Klein Wanzlebener variety of beet in the hands of different farmers will show a variation of from 6 to nearly 20 per cent of sugar, it must be confessed that we have in soil and climatic conditions, and in methods of cultivation, a more potent means of influencing the sugar content of the beet than is found in the germ of the seed itself.

It can only be expected that a sugar-beet seed which is high bred will be able to reproduce its kind when it has become fully acclimated and has received in its new condition the same scientific treatment and selection which it had in its original home. The great hope, therefore, of uniform production of sugar beets high in sugar-producing power in the United States must be found in the establishment of culture stations where different varieties of beets can become fully acclimated, and where they can receive the same careful scientific culture and selection which have brought them up to their present state of excellence in Europe.

APPENDIX.

NOTES ON SUGAR-BEET CULTURE IN FRANCE AND GERMANY.

By WALTER MAXWELL.

These notes are not intended to be a report upon the sugar-beet industries of France and Germany, nor in any measure a statement of the actual present condition of the sugar-growing industry of Europe, but rather as a short record of observations made during a tour through some parts of those countries, and more especially as a repetition of conversations held with certain distinguished authorities.

It will be found that the statements of several of the authorities have already been given in certain of the sugar journals, and are not new; however, it will be of value to repeat these opinions, and particularly in connection with the circumstances under which they were made.

The statements of the authorities cited were made in reply to precise questions, and I have endeavored to reproduce them exactly as they were given.

CLIMATE.

Prof. A. Girard, of the Conservatory of Arts and Industries, Paris, whose studies of the sugar beet are well known, made the following observations:

“The greatest number of our beet-sugar factories are established in that part of France extending from the center to the north and passing through the eastern provinces, where the climate is a temperate one; where the yearly amount of rainfall during the growing season is favorable to an even development of the beet, and where the summer lasts just long enough to mature the roots before the frosts set in. That part of France has been considered the best and the only part adapted to the cultivation of the sugar-beet. Until lately it has been held that beets could not be grown with any measure of success in the south of France, on account of the hot, dry weather which prevails during the summer and the heavy rains in autumn, which cause a second or delayed growth. That opinion has now changed, and two factories are well established in the south—Beaufort, Department de Vaucluse,

which produces 10,000 bags of sugar, and Landun, Department du Gard, thus showing that with proper cultivation, fertilizers, and irrigation the culture of the beet in that part of France is also possible."

Respecting the action of climate upon beets and beet seeds grown in the north and in the south of France, respectively, M. Henri Vilmorin, Paris, said: "

"The influence of climate on the characteristics of the seed of a given variety of beet is not perceptible if only exerted for one year. We had seed grown from the same batch of stock-seed in the north and south of France, and no difference whatever was observed in the features of the roots. The seed from the south, however, was generally of a brighter color, drier, and of a slightly stronger growth."

Although it is held that given climates are specially adapted to culture of the sugar beet, in the words of Professor Girard "the results of more recent experiments, and particularly where the conditions of growth have been largely within experimental control, indicate that it must not yet be said where the beet can not be successfully grown."

SOIL.

"Is there anything to be added to or taken from the opinions of Chaptal, Vivien, or Basset in respect to the soils most or only adapted to the growth of the sugar beet?"

In reply to this question Girard said: "It would take a long time to detail all the kinds of soil which are or can be made suitable to the culture of the sugar beet, since with peculiar culture, the right fertilizers and chemicals, good beets may be grown wherever mangolds succeed. However, it is still held that the kinds of soil which are of a light rather than too compact a texture, containing a given amount of calcareous matters, or having a chalky subsoil, with good natural or artificial drainage, should give the best results. It is well known that fresh soils from old forests or virgin prairies, which are not only acid but also contain an excess of undecomposed organic matter, are unfit for the sugar beet. Lands on which sheep have been fed are likewise in an unsuitable condition to follow with beets for sugar purposes. But this, in some measure, depends upon the variety of beets to be grown. If a soil is full of nitrogenous matter it is, in general, not in a condition in which most beet varieties will grow and form sugar. It has been shown, however, that certain varieties will thrive in such unfavorable (generally) conditions, and this is a matter for special consideration."

Late in September of 1890 a visit was made to the farm and factory of MM. E. Dufay & Co., Chevry-Cossigny, Department of the Seine et Marne. The farm is comprised of some 700 acres, with an annual acreage of beets of about 170 acres. Contracts, which run on with a good understanding from year to year, are made with the large and well-to-do farmers in the immediate neighborhood, whose supplies bring

up the total annual acreage of beets worked by the Dufay factory to about 2,000 acres.

In the course of our conversation upon the nature of Chevry-Cosigny soils and of soils adapted to growing sugar beets, M. Dufay gave me the following data showing the relation of the clay and sand in the soils generally of his farms:

In 1,000 parts of soils.

Clay	707	674	673	629	681	658	680	609
Sand	292	326	327	371	319	340	320	391

M. Dufay said: "I consider a soil which is composed of about two-thirds clay and one-third sand to be well suited for the sugar beet."

But M. Dufay's knowledge of his soils was not limited to the relative amounts of clay and sand of which they are composed. He furnished some equally precise data showing the relative quantities of nitrogen, phosphoric acid, potash, and lime in the soils of his farms, whose clay and sand composition has been given:

In 1,000 parts of soils.

Nitrogen	.96	.97	.99	.94	.98	.80	.94	.83
Phosphoric acid	1.50	1.75	1.75	2.15	1.35	1.80	1.15	1.95
Potash	1.53	2.29	1.91	1.96	2.39	2.53	2.82	3.11
Lime	7.20	10.50	8.50	9.90	8.20	9.70	7.20	.50

M. Dufay said further: "A soil may be said to be well adapted chemically for the culture of the beet when the constituents spoken of are present in the following proportions:

"In 1,000 parts of soil—1 part of nitrogen, 1 part of phosphoric acid, 2½ parts of potash, 30 parts of lime.

"My soils are deficient in lime by two-thirds, and I have to add lime continually. The presence of constituents which act against the formation of sugar, such as the alkali salts, is too small to be observed."

CULTIVATION, FERTILIZATION, AND SEEDING.

With the general principles of cultivation of soils for growing sugar beets we are abundantly supplied on all sides. It is, though, of more interest and special value to know just how certain authorities manage, and what are their ways and methods, who are well known by their great success. It is specific knowledge that we want, and the actual facts from men who, during a length of years, have got great results.

Early in September I went over the farms of Messieurs Vilmorin, Audrieux & Co., at Verrières, near Paris. The farms comprise some 120 acres, which are exclusively used for horticultural and agricultural experiments.

Going over the plots, which were bearing the experimental sugar beets, I put some questions to the practical farm manager and care-

fully took his replies. These data should be of very special interest, as we are speaking of the actual management of the plot of the "Improved Vilmorin" for the year 1890, which is the latest in the series of trials dating from the year 1850.

"What is the soil of this plot, and does the soil vary much over your farm?"

The manager replied: "Just here it is a deep sandy earth and in places almost a sand. In other places it varies from a sandy to a heavier loam. We have no chemical analyses of our soils.

"Although the land lies flat, the natural drainage is in general enough; only in places has it been necessary to put in tile drains, as the beet does not require a dry earth. It is on the whole a dry surface soil lying upon a subsoil of more than average moisture."

"Now, how has this plot been cultivated from the first up to the present?"

"Last October the land was plowed to a depth of 10 inches, and after this plowing superphosphate of lime was added at the rate of 28 grams per square metre. After sowing the fertilizer the land was replowed, and to a depth of 16 inches, and left in that condition till the following April.

"At the latter part of April the land was replowed very deeply, scuffled, harrowed, and rolled until the soil was in a fine state, and the seed was put in."

"What was your mode of light cultivation?"

"As soon as the plantlets were out of the ground far enough to show the rows the hand hoe was used, not coming too near the plants. When the plants had four leaves the thinning out of the plants in the rows commenced. The plants were left 4 inches apart in the row at the first thinning. After the plantlets had grown so far that the roots were almost as thick as the thumb a second thinning took place, which left the plants as they stand—either 8 or 12 inches apart, according as it was determined. In the thinning process care was taken to leave the most promising plants.

"The ground was frequently hoed during the early season of growth to keep down the weeds and to open up and keep porous the surface. The hoeing was done exclusively by hand, no horse implement being used.

"If it is found, as it was this year, that the plants appear weakly, and the young leaves are of a yellow color, a second quantity of fertilizer is added, composed of equal quantities of superphosphate of lime and nitrate of soda, and at the rate of about 30 grammes per square metre.

"It is seen that no farm-yard manure was applied to the land for beets. Usually it is given to the preceding crop, in order that the excess of organic matter may be used up; yet a certain amount remains when the beets are planted. Our method of fertilization is usually as I have given it to you,"

"What rotation, or rotations, do you follow with the land which is used for your seed beets?"

"Our mode of cropping is not a fixed one. This crop of 'mother' beets is growing after the following rotation of crops: 1886, beets; 1887, peas; 1888, wheat; 1889, potatoes (heavily manured); 1890, beets.

"Another rotation which has been followed is, beets, wheat, potatoes, peas, beets. In every case our rotation allows of three years of other crops between the crops of beets."

The practical example of cultivation which has been given applies to the growing of beets exclusively for seed or propagation uses. It will be of value to recite some notes taken from the system of a practical farmer and sugar manufacturer, whose beets were grown for factory purposes.

Dufay made the following remarks to my questions concerning his system of cultivation, fertilizing, and general management:

"Immediately after the harvesting of the grain crop where beets are to follow in the coming year, the ground is broken up about 4 inches deep with the plow, harrowed, and rolled with a 'croskill.' Almost immediately fine farm-yard manure is added, varying from 8 tons to 16 tons per acre, according to the known condition of the soil, and the ground is plowed to a depth of from 8 inches to 12 inches, and in this state left until the spring. I must here insist upon the need of deep plowing for sugar-beets. Where the less quantity of farmyard manure is used the deficiency is made up sometimes by the use of cotton-seed meal, applying about 1,000 pounds per acre, which is done in December, or at the time of deep plowing.

"In the spring, beginning even in March, we commence getting the seed bed ready. Since these operations depend solely upon the nature of the soil, the weather, and other circumstances, a direct rule can not be given. A practical man acts and does just what is best at the time, and a man who is not practical can not carry out a rule. But in a few words, in preparing the soil for the seed of the sugar-beet the end to be reached is to get the earth, chemically and mechanically, into a completely homogenous state; for only in this condition can we count upon a sure harvest of sugar-yielding beets."

In speaking somewhat in detail of the nature and quantity of artificial or chemical fertilizers which M. Dufay applies in addition to the farmyard manure mentioned, he furnished the following formula from his memoranda:

	A.	B.	C.
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Sup. phos. lime.....	1,000	750	1,500
Potass. chloride.....	625	425	425
Amn. sulphate.....	375	250	250
Nitrate of soda.....	850	375	375
Sulphate of lime.....	500	125	125
	3,350	1,925	2,675

The mean cost per acre of the quantities of these fertilizers is about 60 francs (\$12).

The cost per acre of producing the year's crop was given as follows:

Farmyard manure	\$28. 00
Fertilizers	12. 00
Spreading manure	.60
Spreading fertilizers	.25
First plowing	1. 60
Harrowing and rolling after plow	.64
Plowing and subsoiling	4. 60
Two scarifyings	2. 00
Two harrowings	.64
Two rollings	.64
Cost of seed	3. 00
Sowing of seed	.80
Harrowing and rolling again	.64
Three times hoeing with horse	2. 40
Hoeing by hand	4. 80
Harvesting by hand	4. 00
Harvesting by machine	1. 60
Carting to factory	2. 40
Total	70. 61

To the figures stated are still to be added the rent of land and taxes, \$9.40, making a total of \$80.01.

M. Dufay added: "The average per acre is from 12½ to 18 tons. The content of sugar year is 16 per cent of the weight of the beets and 17 per cent in the juice. If my crop averages in any year only 12 per cent of sugar in the beets, then it nearly pays the cost of production. Every pound above 12 per cent. is profit. This year we shall do very well. The only varieties of beets grown by me are the 'Improved Vilmorin' and 'Desprez,' and the seed is obtained each season direct from those firms."

The cost of production per acre given by M. Dufay is high. An approximate estimate of cost, expressed during conversation with a member of the Trotha Bros.' factory, Halle, Saxony, was lower; but the details were not given with such precision as to be worth stating. A general estimation of the cost per acre, furnished me by M. G. Dureau, Paris, though somewhat lower, was about the same as the figures in the Dufay statement.

The question of intensive culture, or high farming, which lies at the very root of success in sugar-beet growing, will be spoken of later and in connection with some other considerations.

SEED BREEDING.

In the course of conversation and communications with such authoritative sources as Messrs. Dippe Bros., Rickmann (formerly Rabbethge & Giesecke), and M. Henri Vilmorin, no very specific data were obtained which have not already been communicated through the journals. A

conversation, however, which was held with M. Henri Vilmorin, and which sets forth the principle and emphasizes the main features of the Vilmorin system of seed breeding, has a value that deserves to be repeated; and more especially in the light of the opinion and comments expressed by Professor Maercker, Halle, Saxony. Maercker said: "It must be admitted fully and by all that the Vilmorin firm had led the way in the improvement of the beet for sugar purposes. In the 'Improved Vilmorin' we had the first great representation of what could be done in the direction of increasing the sugar-forming quality of the beet."

M. Vilmorin spoke as follows: "The experiments for the improvement of the sugar-beet were commenced at Verrières in 1850, by my father. The object held in view was the formation and fixing of a race containing a higher per cent of sugar and a more even composition than the races then in use.

Several methods of selection were successively tried. First, dipping the roots in liquids of great specific gravities. This system was unreliable in the case of the whole roots in consequence of the presence of air cavities in the neck, which made some roots float which should have sunk; and in the use of small pieces or sections of beets fermentation of the liquids was induced, or strong endosmotic effects altered the results.

"Finally, it was found to be more exact to take a small cylindrical piece from the beet and to ascertain the specific gravity of the juice from the pulp. This was done by means of weighing a silver button in the juice. The roots were numbered in each individual and the richest in sugar kept for seed; and the same process was applied to the beets grown from the seed of the previously selected roots or 'mother beets.'

"The process stated was followed till 1872, and the 'Improved Vilmorin' may be said to have been formed by that system of selection, the roots giving juice of the highest specific gravity being held to be the richest in sugar. The office of the polariscope is now added to the above process."

M. Vilmorin continued: "I consider it the most important point in the selection and growing of beets for seed that the roots be grown under such conditions that they freely and fully develop all their good and bad qualities. The system of growing beets for seed on very rich land, but very thickly together, is a great error, as this process hinders the formation of lateral roots, and at the same time greatly increases the content of sugar in the roots, so that they are made to appear of a better form and of a higher sugar quality than they really are. Now, in order to secure a perfectly just appreciation and proof of our 'Improved' beets, they are grown on exactly the same principle and by the same method as beets that are grown for the factory."

The method of cultivation and general management of the plot of "mother" beets on the Vilmorin farm is given on an earlier page, and exactly as received from the practical manager.

In speaking of the system of selection, M. Vilmorin continued :

"Only roots of perfect shape and weighing not less than 600 grammes are tested in the laboratory. Each single root is numbered, which number remains quite legible even after the root has been planted and borne seed.

"The seed of each individual root is harvested separately and kept by itself in a paper bearing the same number that was upon the root.

"The next year a trial is made with a small sample taken from each paper and the bulk of the seed is still kept back till after the roots grown from the sample have been tested.

"This is practiced as a precaution against the possibility of the progeny from a good beet falling far below the accepted standard of quality, which is a rare thing, but by no means unknown, even after long breeding in one line.

"After the previous test, all such beets as have not given satisfactory results are thrown away, and the seed from which such underquality beets were grown left unused. Of course the season and certain other circumstances have to be borne in mind in selections of each year, as in some years roots with 16 per cent of sugar may be relatively better than certain roots containing 20 per cent in some other years. To ascertain, however, the influence of the weather, some good lots of seed have been tested several years in succession and with a view to establishing the variation and error due to climate.

"All the seed that has been proved by the first year's test to be up to the standard of quality is sown the next year, and very thin and carefully, and from it a crop is grown more than a thousandfold the weight of the original seed.

"It is thus seen that any and all seed of the 'Improved Vilmorin' has come from stock-beets weighing not less than 600 grammes, all of which were for successive generations perfect in shape, color, proportion of sugar, and purity of juice; and only once has it occurred, and when the seed was grown for commercial use, that the seed was raised from beets of less size than 600 grammes.

"By the system of severe and unflinching constancy of selection that I have described to you, the 'Improved Vilmorin' beets have been brought to their present high standard of fixed economic qualities.

"The more marked characteristics of our beets are the hardness of flesh, which is at least equal to that of a Swedish turnip, the dull white and rough, rather smooth skin. The leaves, which are numerous, are strong and of a dark-green color, which, in the fall, like the foliage of most beets, droops down around the root."

SOME CHARACTERISTICS OF CERTAIN VARIETIES.

No effort was made to obtain information in general on the number, and constantly increasing number, of varieties which are being put upon the market. Our attention was directed only to one special characteristic, which is found to be the property of some varieties more than of others, viz, the capability of a beet to resist such unfavorable outward conditions of growth as climate, unfitness of soils for beets in general, in consequence of the presence of excesses of undecomposed nitrogenous matter. We shall give the statements of authorities direct on particular phases of this inquiry.

Franz Schindler, professor in Riga, said: "All the three types, Vilmorin's Improved White, Vilmorin's Early Rose, and the Improved (with Vilmorin) Klein-Wanzlebener, developed exactly their proper characteristics as well in Kwassiz, Moravia, as in the neighborhood of Riga, Russia, although the latter place is about a thousand miles farther north than the former. And all three types remained true not only in point of sugar content and other biological qualities, but also in anatomical structure. The climate of the two places is extremely different, and, moreover, the beets were grown in Kwassiz in an excellent beet land and under correct cultivation, while at Riga they were raised on a sandy soil rich in vegetable mold and largely manured with stable manure.

Now, it has been found by Deherain, in France, and also by Schindler and de Proskowetz in Russia that "the Vilmorin beets contain a higher proportion of fibrous to cellular tissue than any other types of sugar beets, and the amount of sugar being correlative with the fibrous tissue the higher sugar content is easily understood."

From notes sent by MM. Jacquemart and Delamotte, sugar growers and manufacturers at Quessy, Department Aisne, "beets of the 'Improved Vilmorin' were grown comparatively on the same field with doses of nitrogen amounting respectively from $37\frac{1}{2}$ to 75 pounds per acre. The drought interfered with the action of the manure, but it was seen that the beets grown with the double allowance of nitrogen were of better quality than the others."

The value, respectively, of the types and kinds of beets is regulated by other conditions than the content of sugar—such as the production by weight per acre, etc. Professor Maereker said: "For a time the 'Improved Vilmorin' almost entirely substituted the Klein-Wanzlebener in Saxony on account of its high content in sugar. It has been found, however, that the 'Improved Vilmorin' does not produce the weight per acre, and has not succeeded as well with us under certain indifferent conditions as the Improved Klein-Wanzlebener. Consequently in our district (Halle and Magdeburg) the Improved Vilmorin has been replaced largely by a cross between the Improved Vilmorin and the Klein-Wanzlebener, which cross very specially combines the richness in sugar

of the former variety with the greater productiveness by weight of the Klein-Wanzlebener."

There are two fundamental economical conditions which control very largely the varieties of beets which shall be grown, in addition to the climatic and soil conditions, of which we have already spoken. Those conditions are: The system of taxation obtaining in each district or country. If the taxes are levied on the weight per acre of the roots, then it is specially advantageous to have the largest quantity of sugar contained within the smallest weight of raw produce or beets. If the tax is upon the manufactured product, the condition does not exist in the same form. The second fundamental condition regulating the variety of beets to be grown is devolving upon the consideration as to whether the beet crop is being grown exclusively for the sugar without secondary purposes, or whether the beet crop, as well as being grown as a direct source of profit in the form of sugar, is cultivated as part of a large and general rotation of cropping. Upon farms where live stock and the providing of food for such is an essential item in the economy, the difference between 20 tons and 35 tons per acre of beets is to the farmer a weighty consideration and often a decisive condition.

The substance of the observations made to me by many sound authorities on the relative and particular merits of respective varieties have inclined me to the following conclusion: As a variety for the highest and most concentrated production of sugar, for the withstanding of the unfavorable effects of certain climates and soils, and for use in new soils and such as are not habituated to the growth of the beet plant, no better beet can be adopted than the Improved Vilmorin. And again, as an all-round valuable beet, suitable to the farmer as a source of direct profit and as part of his system of mixed and general agriculture, as well as to the manufacturer of the sugar, the Improved Klein Wanzlebener is spoken of with unhesitating recommendations.

ECONOMICAL CONSIDERATIONS.

Many conversations were held with well-known authorities in France and Germany upon features of the sugar-beet industry that may be termed more specially economic. The substance of what was obtained will be given as the result of a conversation with Professor Maercker on some of the economic features of the industry. In conclusion will be given a conversation held with M. Tisseraud, permanent secretary of the department of agriculture of the Government of France.

Professor Maercker, in reply to questions, made the following remarks: "Owing to the very nature of the manufacture of sugar from beets, in which large and costly machinery plants are necessary, it is not possible for small owners or holders of land to grow beets and to make sugar therefrom on their own farms. The acreage of beets grown by such farmers individually could not pay for the investments necessary to the manufacture.

"There was only one of two courses by which it was possible to introduce beet culture among farmers generally, and as a great and general industry. The first method by which it could be done was by the farmers contracting with the large growers and owners of factories to grow a given acreage of beets and deliver the same to the factories under given conditions, as is the system in France. A second system was the uniting of the farmers among themselves and thus forming manufacturing companies (*Actien Fabriken*). The articles of these corporations or companies require that each member shall supply a given acreage or weight of beets to the factory, and according to conditions fixed upon by the board of control.

"With the founding of the latter system, which is the prevailing one with us, the growing of beets by the great farming class in the beet districts became solidly established. It was the opening of a new era of agricultural prosperity when the industry was made to prevail. The small owners and farmers, whose farms are comprised generally of from 50 acres to 120 acres, and quite exceptionally reaching 250 acres, became manufacturers of sugar as well as growers of the beets by accepting a direct interest in the owning and conducting of the factories."

In reply to the question "Have the owners of large private factories or the companies paid the best? And which system has done most for the industry?" Professor Maereker replied: "The undertakings of the large owners (*gross Herren*) are conducted with method and have the advantage of large capital, but there is not the degree of enterprise and care of detail characteristic of the companies (*klein Herren*) as represented by the farmers.

"The '*klein Herren*,' being practical farmers, are well up in thorough and economical culture. They enter into the industry with the care and enterprise which their smaller conditions have always forced upon them; and as regards the technical or manufacturing part of the industry the companies composed of the farmers have shown an intelligence, ingenuity, and enterprise which has placed them in advance of their competitors of the '*large system*.' The companies were the first to introduce improved methods of extracting the sugar from the beets, such as the diffusion method.

"Our farmers are in good circumstances, which have been improved with their general system of agriculture by the introduction of the sugar-beet industry. They are rich and free."

The German has most decided features of advantage over the French system. In Germany the growers of the beets are the manufacturers, and they reap a gain in the growth of the beet and the production of the sugar.

The system of farmers supplying beets under contract to large factories always places the growers at some measure of disadvantage; and where factories are large and isolated in wide districts, and the factory owners have little interest in the general agricultural interests, the result to the farmer may be, and is often, calamitous."

To M. Tisseraud, who is the permanent secretary of the department of agriculture of France, and who is not only conversant with the sugar-beet industry of France, but of whom it may be said that he holds French agriculture in his right hand, we have to express our obligations, not only for the general candor and copiousness with which he replied to our inquiries, but also for a very special politeness in causing certain data for the current year (1890), which had not at that time been published, to be furnished to us in manuscript.

The following observations were made in reply to certain carefully prepared questions which were put to the secretary in the order in which his remarks proceed:

"The very nature of the cultivation of the beet tends to make it an industry more adapted to growers, if not essentially on the large scale, at least who are not small in the sense that our peasants are, who cultivate from 5 to 10, or even from 20 to 30 acres. The culture of the sugar beet, if it is to be a success for the making of sugar, must be done well. The grower must be a man of capital, who can invest liberally per acre in the form of modern implements, of abundant labor, both manual and animal, at the right season, and who can purchase largely and with judgment of chemical manures, such as superphosphates. The soil must be plowed deeply and cultivated thoroughly, which means good implements and horses; it must be kept in clean condition, which means much labor; and it must be well fertilized with costly manures, which means a large outlay. Now, these conditions of the successful culture are not within the compass of our small peasant farmers. The larger farmers, *i. e.*, such as occupy enough land to bear investment in implements, labor, and manures, are capable of growing beets with as great success as the owners and holders (tenants) of the large tracts which exist in the districts where our sugar industry is making the greatest progress."

"What is now the tendency in France in respect to the 'large *vs.* small' system of beet culture?"

"The tendency is toward obtaining large tracts of land, where the heavy investments, in labor, implements, and manures, of which I have spoken, can be made most remunerative, and the facilities for manufacture of sugar are most complete. In the northern departments of France, where the culture is on the large system, the industry is expanding and gaining the most ground."

"What has been the effect of legislation upon the development of the sugar-beet industry, agriculturally, and also through the beet industry, upon your agriculture in general?"

"Before the year 1884 the farmers who grew beets to supply the factories had no interest in producing beets of high quality and with a large content of sugar. The law, as it at that time existed, made it most advantageous to the farmers to produce weight or quantity, as it was not merely the same to them in the price per ton that they ob-

tained. They also grew a much larger weight per acre for sale and had a correspondingly larger amount of pulp for feeding their cattle. The manufacturers, on the other hand, were being ruined by the operation of the law of that date. (See the law before 1884.) The law of 1884, however, altered these conditions. Under this law it became necessary to grow beets with a higher content of sugar, which not only were worth manufacturing, but which were found to be equally worth growing by the farmers, as the sugar factories were able to pay the growers \$6 to \$7 a ton instead of \$4 to \$5, as had been formerly paid. This change in the law affecting the sugar industry brought about the great improvement in the culture of the beet which has occurred in the last few years. In the first place, the improvement of the seed has taken the lead in consideration, and varieties have been produced and grown which were very rich in sugar. In the second place, the modes of cultivation have been improved and the application of chemical fertilizers increased up to the standard of the most intensive culture or high farming, all of which conditions are the essential factors of success in growing sugar beets."

"Are you of opinion that the successful growing of beets for a sugar-making purpose is only possible where 'intensive culture' or high farming obtains?"

"That is strictly the case. Sugar beets pay better than any other agricultural crop for high culture, and they can be made to pay only where 'high farming' is practiced. If you grow beets, grow the best that high culture can produce. Unless you farm well, have land in high condition, with liberal manuring and abundant labor, don't attempt to grow beets. Grow wheat, potatoes, or what you like, but don't grow beets. * * * We are not only increasing our productions in comparison with former periods, we are holding our place in competition with the world."



80
95

UNIVERSITY OF ILLINOIS-URBANA



3 0112 051005251